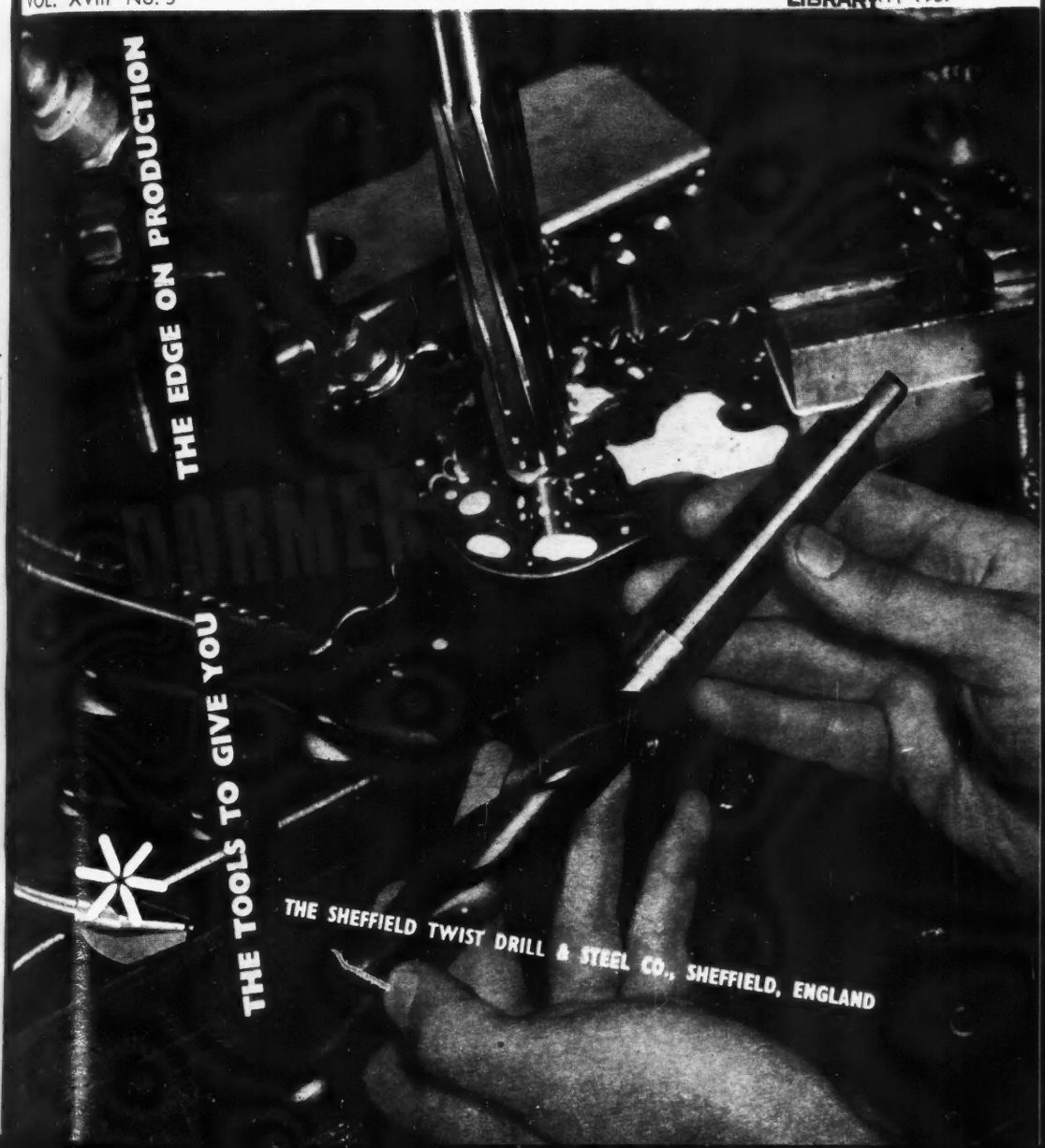
The
ENGINEERS' DIGEST

REVIEW OF WORLD ENGINEERING PROGRESS

VOL. XVIII No. 5 MAY, 1957

JUN 10 1957
ENGINEERING LIBRARY



Engineered for endurance

This robust pump will ensure a longer life of useful service.

Cast iron and steel with steel backed lead bronze bearings. Gaskets and glands not subject to pressure. Steady flow. Hydraulically balanced.

MA 3/0 GEAR PUMP
700 g.p.h. at 720 r.p.m.
1,000 g.p.h. at 960 r.p.m.

MEASUREMENT LIMITED

Manufacturers of Liquid Meters, Rotoplunge Pumps, and Control Apparatus

119 UNION STREET • OLDHAM • LANCS

Telephone : Oldham MAin 6432 *Telegrams : „SUPERMETER", Oldham*

A Member of the Parkinson & Cowan Group

---

now
WRITE FOR A NEW BOOKLET

"Cronite"

REGD. TRADE MARK

The HIGH TEMPERATURE ALLOY

SALT, LEAD AND CYANIDE VESSELS
CARBURIZING BOXES AND POTS
ROTARY RETORTS & PROPELLING WORMS
FURNACE HEARTHS AND FITTINGS
ENAMELLING PERRITS AND SUPPORTS
GLASS-BLOWING NOZZLES
PYROMETER PROTECTION SHEATHS
CASTINGS FOR USE AT 700 1200 C.

The
CRONITE FOUNDRY Co. LTD.
LAWRENCE RD · TOTTENHAM · LONDON N15
PHONE · STAMFORD HILL 4237

CONTENTS

	Page
The Blue Pages	185
Surface Contacts with High Loading Pressures in Corrosive Atmospheres	189
The Changes Produced in an Air Stream by Wire Gauze	191
New Developments in Silicone-Rubber Compounds for Extruded Electrical Insulation	194
Dynamic Tooth Forces	197
Accelerated Fatigue Testing of Plastics	201
Flame Washing of Steel Castings	203
Investigations of Sliding Contacts used in Electrical Measuring Circuits	205
New Torque-Meter with Dynamometer Ring	208
British Industrial Developments	209
Additional Abstracts	214
New Materials, Processes, and Equipment	216
Instruments, Electronics & Automation Exhibition	221
News of the Month	224

The ENGINEERS' DIGEST

REVIEW OF WORLD ENGINEERING PROGRESS

VOL. XVIII NO. 5 MAY, 1957

EDITORIAL AND ADVERTISING OFFICES ;

GREAT BRITAIN
120 Wigmore Street, London, W.1
Telephone : WELbeck 9357 & 6263

U.S.A.
366 Madison Avenue, New York 17, N.Y.
Telephone : MUrray Hill 2-8865

FRANCE
102 Rue Amelot, Paris (XI^e)
Telephone : VOL. 29-19

ITALY
Via Gran Sasso N.28, Milan
Telephone : 208.741

Annual Subscription Rates ;

£2 2s. 0d. in the Sterling area, $7.50 in the Dollar area

Printed in Gt. Britain by THE ALCUIN PRESS, Welwyn Garden City, Hertfordshire, and published monthly by the proprietors, ENGINEERS' DIGEST LTD., 120 Wigmore Street, London, W.1.

PITMAN BOOKS

PETROLEUM AND ITS PRODUCTS

By J. H. van der Have and C. G. Verver. Explains the how and why of the methods used for obtaining crude oil and converting it into finished products. **50s.** net.

A HANDBOOK OF INDUSTRIAL WELFARE

By R. R. Hopkins, M.I.P.M., etc. A practical handbook which summarizes the factors that arise in applying a welfare programme in a business concern. **17s. 6d.** net.

STRENGTH OF MATERIALS

By F. V. Warnock, O.B.E., M.Sc., etc. A new and revised eighth edition of this book—the standard work on the subject. Pitman's Engineering Degree Series. **25s.** net.

THE GEOMETRY OF SHEET METAL WORK

By A. Dickason. **15s.** net. "Destined to rank for all time as a standard treatise on the subject covered."—Foundry Trade Journal.

THEORY OF STRUCTURES

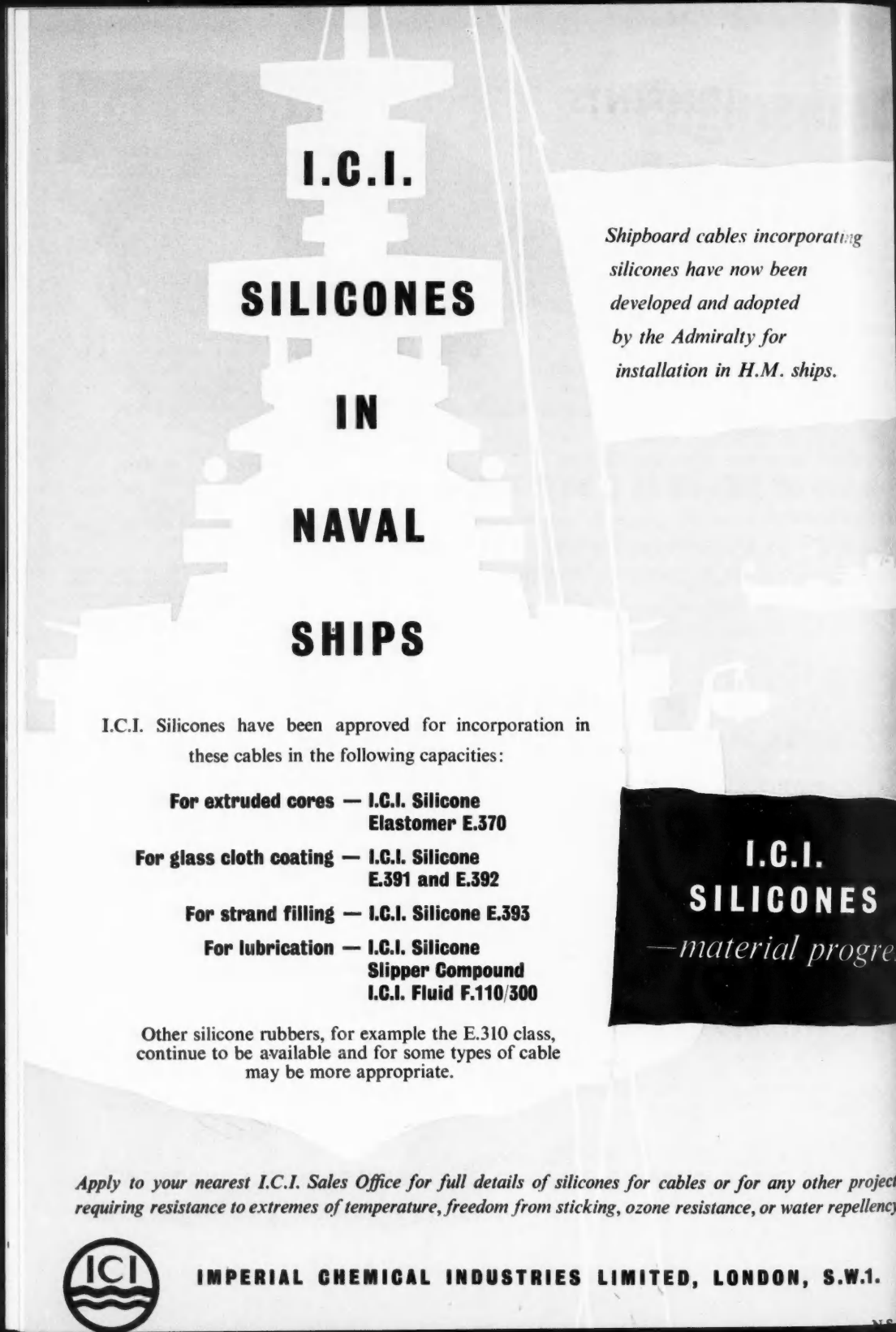
By H. W. Coultas, M.Sc., B.Sc., etc. 4th Edition. A comprehensive book long recognized as a standard work on the fundamental principles of the theory of structures. **25s.** net.

MANAGEMENT, LABOUR AND COMMUNITY

Edited by D. Cleghorn Thomson, M.A., etc. A symposium of the writings of 22 of the nation's experts in management and human relations. **35s.** net.

SIR ISAAC PITMAN & SONS LTD.

PARKER STREET, LONDON, W.C.2.



I.C.I. SILICONES IN NAVAL SHIPS

Shipboard cables incorporating silicones have now been developed and adopted by the Admiralty for installation in H.M. ships.

I.C.I. Silicones have been approved for incorporation in these cables in the following capacities:

For extruded cores — I.C.I. Silicone Elastomer E.370

For glass cloth coating — I.C.I. Silicone E.391 and E.392

For strand filling — I.C.I. Silicone E.393

For lubrication — I.C.I. Silicone Slipper Compound
I.C.I. Fluid F.110/300

Other silicone rubbers, for example the E.310 class, continue to be available and for some types of cable may be more appropriate.

I.C.I. SILICONES
—material progress

Apply to your nearest I.C.I. Sales Office for full details of silicones for cables or for any other projects requiring resistance to extremes of temperature, freedom from sticking, ozone resistance, or water repellency.

ICI

IMPERIAL CHEMICAL INDUSTRIES LIMITED, LONDON, S.W.1.

THE BLUE PAGES

A QUICK GLANCE AT THE LATEST TECHNICAL DEVELOPMENTS THROUGHOUT THE WORLD

● *METHOD OF HOT-DIP COATING WITH ALUMINIUM*

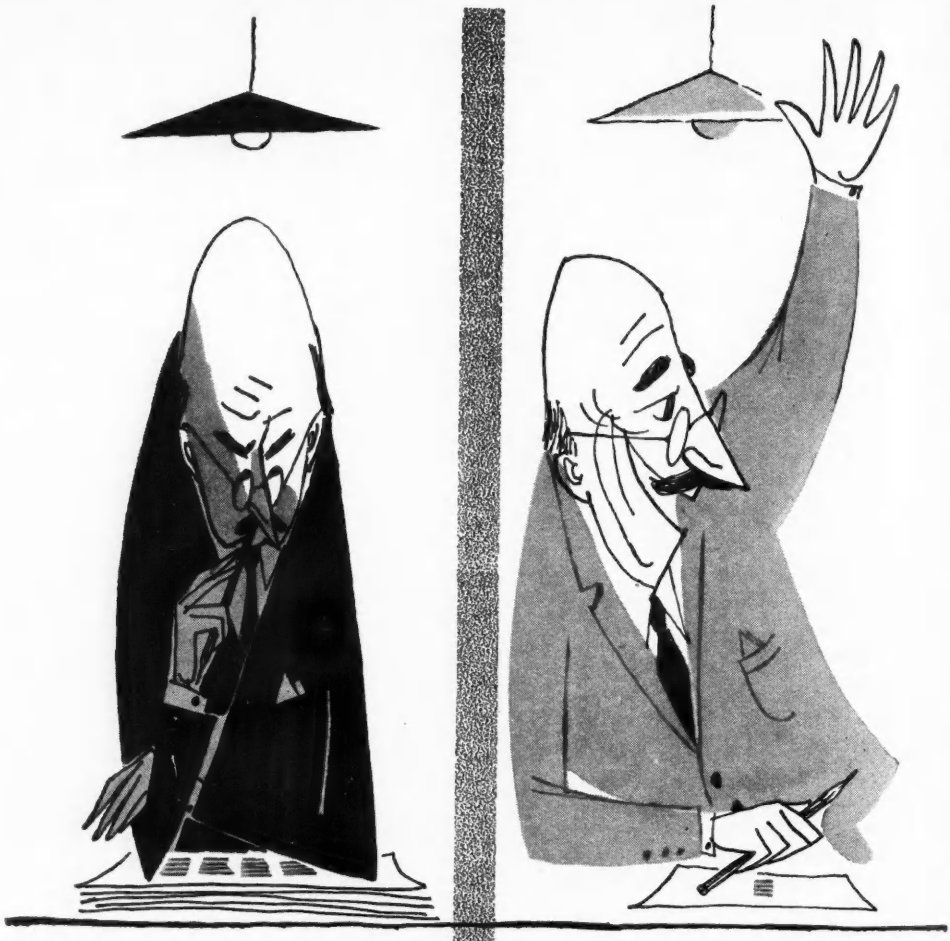
In the dip-coating of metals, especially iron and steel, with aluminium or aluminium alloys, it is customary to employ either molten fluxes or neutral atmospheres above the bath to facilitate the production of satisfactory coatings. A recent patent specification states that the use of fluxes or neutral atmospheres increases the cost of carrying out the hot-dipping process, and that certain aluminium alloys cannot be used economically and satisfactorily in hot-dipping, owing to the slow speed with which these coatings are formed. It has now been discovered that the addition of a small amount of sodium or potassium or of a sodium-potassium mixture to the aluminium bath makes it possible to increase coating speed and to dispense with the need for fluxes or neutral atmospheres. It is claimed that bath life will also be increased, and that the evenness and smoothness of the coatings are also improved. After first skimming the aluminium bath, a quantity of metallic sodium is then plunged below the surface of the bath and stirred. After a relatively short time some of the sodium will be absorbed in the bath, and the excess will either be fumed away or converted to a dross on the surface. The bath is then skimmed carefully and is ready for use. The appearance of the bath surface is said to be brighter than it was before the sodium treatment and to remain bright for a longer time after skimming. The cleaned piece is immersed directly in the bath without a protective atmosphere or flux, and is withdrawn after a few seconds with an even and smooth coating. It is recommended that, for optimum coating speed, between 0·001 to 0·1% by weight of sodium and/or potassium should be present in the bath.

● *IMPROVED METHOD OF MANUFACTURING ROLLER- AND BALL-BEARING RACE MEMBERS*

A recent patent specification describes a novel method of manufacturing the race members of roller and ball bearings, its object being inhibition of their permanent distortion under working conditions. The components of bearings manufactured by conventional methods may, it is stated, take a permanent set under working conditions to such a degree that the bearing becomes unfit for further service long before the working surfaces of the components have suffered any serious damage or deterioration. The new method proposes a sequence of operations involving mechanical pre-stressing of the bearing rings, in combination with grinding, resulting in finished race members which can withstand the service for which they are designed without suffering permanent distortions. In the new process, a final grinding is given to all those surfaces in which the effect of the subsequent permanent set can be neglected, such as those which are not track surfaces and which do not require an accurate finish. All other surfaces, e.g., track and housing-fitting surfaces, from which it is desired to eliminate distortions due to a permanent set, are only partially finished, the excess size allowance being sufficient to enable superficial distortions to be subsequently ground out by a finish-grinding operation. Mechanical pre-stressing is then applied to the race member so as to produce a permanent set, after which the over-size surfaces are finish-ground, thus leaving a finished race member of the correct dimensions but in a mechanically pre-stressed condition. The mechanical-stressing operation is conveniently effected by applying a load to the working tracks of the partially finished race member through slave rollers or balls which are caused to roll round the tracks in a way similar to that followed by the rolling elements of the finished bearing. When this load is applied, the ring distorts and takes a permanent set.

● *PREVENTION OF CAVITATION EROSION IN DIESEL-ENGINE COOLING JACKETS*

It appears that resonant vibration of the cylinder liner of a diesel engine, as excited by the impacts of piston slap and cylinder firing pulses, is one of the important factors in causing cavitation erosion. Thus, any measures that can be taken to reduce vibration will have a beneficial effect. In fact, it is reported that no material can resist pitting, if the amplitude of vibration exceeds 0·003 in. Two methods of reducing vibration of cylinder liners are (1) reducing piston clearance and (2) increasing liner-wall thickness. Vibration tests have indicated, for example, that liner-wall vibrations can be reduced from slightly over 0·006 in. for a thin-wall liner of 0·156 in. with a production piston



Meet Mr. Frost the accountant
Old Jock to his colleagues on the Board ; Old Misery Guts to the chap in charge of the boiler room. Could *he* help it if fuel prices keep going up ? What this plant needs is really efficient insulation.

Meet Mr. Frost
now known behind his back as Jolly Jock. He grumbled about the cost of having the boiler and pipes insulated with Fibreglass. But since he saw how much fuel it saved, he's even said Good-morning to the boilerman.

wrap that plant in

FIBREGLASS
TRADE MARK

FIBREGLASS LTD., ST. HELENS, LANCS.

to less than 0·001 in. for a two-piece heavy-wall cylinder of 0·25 in., with a piston having 20% less clearance. The use of a harder or more corrosion-resistant material for the liner also lessens cavitation erosion. It is reported that the cavitation erosion experienced in a diesel engine has been completely eliminated merely by changing the material of the liner to copper-chromium-iron. Both non-metallic coatings and platings of various types have also been found helpful in reducing cavitation erosion. In this connection, one investigator has obtained optimum results with a 0·003-in. nickel plus 0·01 in. chromium plating. Another investigator reports that especially good results were obtained with self-regulating chromium plate, this being ascribed to the fact that the self-regulating chromium plate has about 3000 grains per square inch, as compared with 720 grains per square inch for conventional chromium plate. Copper plating can also be used, but it has been found important to ensure that the copper is properly bonded to the sleeve surface.

● *BRAZING PROCEDURES FOR STAINLESS-STEEL HONEYCOMBS*

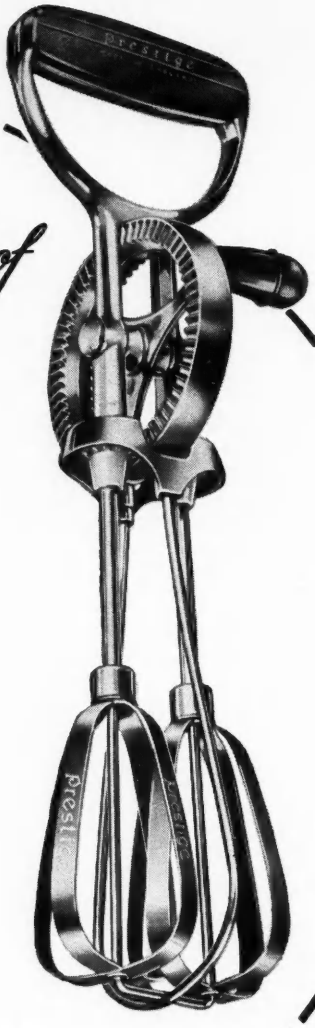
A recent report claims that one of the most promising materials for supersonic aircraft and missiles is a welded stainless-steel honeycomb core with brazed face sheets and close-outs. This material is stated to meet most closely requirements for a high strength-to-weight ratio and the ability to withstand the high temperatures generated by atmospheric skin friction. The honeycomb core is made of stainless-steel foil, 0·001 to 0·003 in. in thickness, and is formed by resistance-welding adjacent nodes of the formed foil. Cells may be hexagonal, square, or other shapes, $\frac{3}{16}$ to $\frac{3}{4}$ in. in width, and core depths may be as much as 9 in., or even more. Other materials, such as mild steel and tool steels, have been tried, but have been found unsuitable for this purpose. Brazing appears to be the most promising fabrication method, and the brazing alloys which are being studied melt at 1600 to 2000°F, a rule-of-thumb requirement being that the melting point of the brazing alloy should be about twice the operating temperature. Particularly suitable for the purpose is silver-manganese, either as a binary alloy or containing small amounts of lithium, nickel, chromium, iron, cobalt, or copper. The brazing alloy must have good wetting power and corrosion resistance ; in addition, it must not decrease the strength of the parent metal by intergranular penetration. One alloy is not, however, sufficient, as fabrication techniques require a complete family of alloys, so that multiple-stage brazing can be carried out. While honeycomb-sandwich materials have excellent strength and oxidation resistance at 600 to 800°F, they are all reactive at high temperatures, so that they must be protected during brazing. Several brazing methods are therefore being studied, including retort brazing, vacuum brazing, induction brazing, electric-blanket brazing, blow-torch brazing, radiant-lamp brazing, and salt-bath brazing. Of these, retort brazing, in which the part and its tooling are placed in a protective retort located in a conventional high-temperature furnace, is at present the most favoured, mainly because furnace equipment can best be adapted to it. However, despite the considerable expenditure required for new equipment, vacuum brazing seems the most promising method, by virtue of its important advantages, including the fact that brazes made in a vacuum are generally stronger than those made in inert or hydrogen atmospheres, and that the use of a vacuum furnace obviates the use of complicated retorts and the costs of inert gases.

● *DIRECT-READING TECHNIQUE FOR THE DETECTION OF DEFECTS IN SHIP WELDS*

The failures experienced with welded ships make it desirable to have a reliable and fairly simple means of flaw detection in ship structures. Unfortunately, conventional radiography, even if applied to selected sensitive locations in the midship structure, is costly and time-consuming, so that a more convenient method would greatly contribute towards the general acceptance of flaw detection in shipbuilding. Recent investigations are concerned with the feasibility of a direct-reading or filmless technique in radiography, using a cobalt-60 source and a Geiger counter. For this purpose, tests have been carried out on a welded test plate, 1 in. in thickness, the tests being based on transmitted radiation and the time required for a preset number of counts on a chronograph constituting a function of the radiation intensity passing through a specific area of the weld. The larger the void, the shorter is the time indicated on the counter. A comparison of the densities of the testpiece radiograph has indicated a fair degree of correlation, and the minimum void depth detected by the counter was 6% of the 1-in. steel. Preliminary tests also indicate that it is feasible to place both the radiation source and the detector on the same side of the weld and to use a lead-sheet radiation scatterer on the other side. Experiments have also been carried out with the use of X-ray equipment in place of the gamma-ray source. The detectors used in these tests were a scintillator, an industrial Geiger counter, and cadmium sulphide and cadmium selenide crystals, the scintillator being found to be the most useful detector of gamma radiation. It is reported that further experiments, using a 2000 mC cobalt-60 gamma source, are now in course of progress.

Prestige

is something to be proud of



One of the most interesting features of the Prestige ' Imperial ' Food Mixer, is that the makers give with it a five-year guarantee. We regard this guarantee as a fine tribute to the quality and prestige of our castings which form the body, handle and gear.

As the demand for quality die castings has risen it has been a matter of regret that for some time we have been unable to accept orders from new customers.

In order to satisfy demands from new customers we have completed a major development programme. We are now even better equipped to give you an excellent service and welcome your enquiries.

Photograph reproduced by kind permission of The Prestige Group Ltd.

30 YEARS' ANGLO-AMERICAN DIE CASTING EXPERIENCE

WOLVERHAMPTON DIE CASTING
AFFILIATED WITH
PRECISION CASTINGS CO. INC. (U.S.A.)

CERTIFIED ZINC ALLOY ZAMAK DIE CASTERS

THE WOLVERHAMPTON DIE CASTING COMPANY LIMITED

GRAISELEY HILL WORKS · WOLVERHAMPTON · TELEPHONE 23831/6

• *METHOD OF PRODUCING TARNISH-RESISTANT SURFACES ON ALUMINIUM*

A recent report points out that wheel buffing and polishing produces on most aluminium die-castings a surface which soon tarnishes unless it is plated or otherwise protected. It is known that a high lustre can be produced on substantially pure aluminium and that it will remain bright for long periods without a protective coating; however, on die-casting aluminium alloys, the lustre is sensitive to finger-prints and does not remain bright, this being attributed to alloying ingredients on the surface. Experiments have shown that, if the alloying elements on the surface are removed by acid etching, and if ball-burnishing in a barrel is then carried out, it is possible to obtain a brilliant finish which is stain-free, affords prolonged resistance to tarnishing, holds its colour well, and does not show finger-prints. The parts to be etched are cleaned in a hot controlled-etch alkaline cleaner, rinsed twice in cold running water, and are then dipped for a few seconds in a concentrated solution of nitric and hydrofluoric acids at room temperature. This carefully controlled solution attacks and etches out alloying elements on the surface of the castings, but does not readily attack the aluminium, which is left in essentially pure form. Acid etching is followed at once by two cold-water rinses, and care is taken to keep the castings wet until they are placed in the barrel, the balls for burnishing being so chosen that they will reach into fillets and recesses, but will not lodge in holes in the castings.

• *ELECTROPLATING OF LIGHT METALS FROM ORGANIC SOLUTIONS*

It is reported that several refractory and light metals or their alloys, including beryllium and alloys of magnesium, titanium, or zirconium with aluminium, can now be electroplated from organic solutions. These deposits have been produced by plating techniques developed in connection with investigations concerned with the electrodeposition of metal coatings and with the electroforming of refractory metals. In the course of this work, improvements have also been made in a process for electrodepositing aluminium, but, with the exception of aluminium, plating of refractory and light metals is not yet commercially practicable. Refractory and light metals have many special properties which make them important in industrial applications. Thus, titanium and zirconium are corrosion-resistant and have relatively high melting points, and would therefore be very valuable either as protective coatings on other metals or for electroforming. However, their deposition potentials are so far above hydrogen in the electromotive series that they cannot be deposited from aqueous solutions. It was therefore decided to investigate fused salts and organic solutions as baths for electrodepositing light and refractory metals, the best deposits of these metals being obtained from halides, hydrides, borohydrides, and organo-metallic compounds, dissolved in ether. Fused salt baths yielded the metals only in the form of powder, flakes, or dendrites. Electrodeposits of pure titanium and pure zirconium have not as yet been obtained from organic solutions, but alloys of these metals with aluminium were deposited from ether solutions containing complex metal compounds. The alloys produced were titanium-aluminium (6% Ti) and zirconium-aluminium (45% Zr). Satisfactory deposits of magnesium-aluminium (6% Mg) were also obtained.

• *MEASUREMENT OF THE CORROSION RATE OF IRON BY POLARIZATION TECHNIQUES*

In corrosion-rate measuring techniques, the extent of corrosion is usually expressed in such terms as weight loss or pit depth. When the degree of corrosion is based on weight loss, the test specimens must be exposed for sufficiently long periods to render cleaning errors negligible in comparison with weight loss. Also, in order to study the effect of exposure time on the rate of corrosion of a given material, removal of individual specimens at given intervals must be effected, and under these conditions results will depend on the uniformity of the electrolyte. If this electrolyte is a soil, the corrosion rates of similar specimens will differ, unless the degree of aeration around each specimen is the same. A new method of measuring corrosion rates, in which these disadvantages are overcome, is based upon the observation that the corrosion rates of specimens of low-carbon steel exposed in the laboratory to soils can be measured electrically by analysis of cathodic polarization curves. The sensitivity of this technique as a means for measuring relative rates of corrosion was studied by simultaneously exposing aluminium-killed and silicon-killed carbon steels of approximately the same composition for two weeks. Also included were additional specimens of the same steels after water-quenching from 1650°F. Neither polarization nor weight-loss measurements revealed any differences in the corrosion rates of aluminium-killed or silicon-killed steel specimens, but both methods of measurement showed that quenching presumably causes the rates of corrosion to be slightly increased. The sensitivity of the polarization method was further explored by using automatic equipment for recording cathodic polarization on simultaneously exposed low- and medium-carbon steels. The corrosion rates calculated from the polarization curves were found to be within $\pm$ 5% of the corrosion rates shown by the actual weight losses.

COLD DRAWN CAROBRONZE for BUSH BEARINGS

SAVE LABOUR MACHINING MATERIAL WASTAGE

HIGH QUALITY COLD DRAWN PHOSPHOR BRONZE TUBES & RODS TO WITHIN A FEW THOUS. OF INCH OF FINISHED COMPONENTS

Registered Trade Mark

FULL RANGE OF STOCK SIZES

Ask us for complete stock and price list.

CAROBRONZE LTD

SCHOOL ROAD, BELMONT ROAD, LONDON, W.4

Wins on points

How can we be so sure of the superiority of TURQUOISE pencils? Because every process in their manufacture is tested and proved in the EAGLE testing rooms to give long and satisfactory service Use TURQUOISE always.

THIS REFLECTOMETER checks blackness for grading

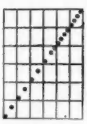
Test charts of pencil shadings, held under the electric eye of the Reflectometer, register on the dial as exact percentages between black and white. Opacity to a fraction of one per cent is recorded.

THIS GIANT PENDULUM proves the smoothness of a lead

As the point of the lead presses on to the paper the friction slows or stops the pendulum. The smoother the lead, the longer the pendulum swings, thus determining the relative writing smoothness of different lead formulas. The 540-lb. bob swings freely, making 49,920 oscillations from a single impulse before coming to rest.

THIS PRESSURE SCALE breaks points so that you won't

The pencil is pressed down on to the plate at the normal writing angle. The dial indicates the exact pressure required to break the point.



THIS CHART shows difference in hardness

This chart illustrates the exact difference in hardness between each degree. Because the technical user requires great accuracy they are spaced twice as closely from F to 9H.

THIS METER tests length of line

On this revolving drum the pencil makes a continuous line, which is measured by multiplying the circumference of the drum by the number of revolutions, and thus tests the durability of EAGLE pencil leads.

CHEMI-SEALED TURQUOISE DRAWING HB

T13

SEALED TURQUOISE DRAWING HB

EAGLE

'CHEMI-SEALED' *Super-bonded*

TURQUOISE

DRAWING PENCILS

with **100% 'ELECTRONIC'** *Graphite*

EAGLE PENCIL COMPANY, ASHLEY ROAD, TOTTENHAM, N.17

• *TESTER FOR MEASURING THE TORSIONAL YIELD POINT OF SPRING WIRES*

A new design of wire tester, developed for measuring the torsional yield point of spring wires, is basically a simple device designed to twist a known length of wire about its axis through a known degree of angular deflection. When the load is released, the amount of permanent deflection or set in the wire is measured. When the angular set reaches an amount equal to 2% of the angular deflection given in the test, this value is arbitrarily called the 2% set point. No load measurements are taken, but the stress is computed from the wire dimensions, the deflection, and the modulus of rigidity. It is proposed that this test should be employed in place of the tensile test commonly used by spring makers, because, although the tensile test is rapid and reproduceable, and has provided a set of quality standards which are quite workable, it does not provide a true method of predicting spring performance. In fact, it is not necessarily a pertinent measurement, nor is it sufficiently sensitive, and it is of meaning only in the light of previous data. A helical compression spring is stressed in torsion ; it may fail in service by setting, i.e., by exceeding the torsional yield point. The value of the torsional yield is therefore a design criterion which may be used directly in calculating the load which a spring can safely carry without excessive set. It is reported that the new testing procedure has also proved to be sensitive in wire-development research, and it may therefore be possible to use this test as a wire quality-control technique to yield design data directly applicable to spring-design problems.

• *HARDENING PROCESS FOR LONG CARBON-STEEL TUBING*

A recent invention is concerned with a process for hardening long tubes or other elongated hollow bodies made of carbon steel. It is stated that one field in which this invention has been found to be especially applicable is the hardening of tubes for oilfield use. These tubes, e.g., pipe-liners, have in the last few years been increasingly used for petroleum bores of relatively great depth, and requirements for the strength of such tubes are increasing accordingly. Alloy steels were first used as the tube material, and efforts were then made to bring unalloyed carbon-steel tubes to the desired strength by heat treatment. This was effected by chilling the heated tubes from the hardening temperature by means of a water spray and by subsequent drawing treatment. However, the tubes became distorted during the chilling operation and became relatively oval, and all efforts to obviate such distortion and ovality are said to have been unsuccessful. The object of the new process is stated to provide a method which eliminates these defects and which at the same time speeds up manufacture. Briefly, the process provides for hardening the tubes from the inside by passing a coolant helically along the inner surface of the tube at high speed, this speed being defined as that at which the coolant travels when it is ejected from a nozzle at a pressure between 6 and 12 atm. The actual range of speed to be used in a given case will, of course, depend on the size of the tube and other conditions, such as the nature of the internal wall surface of the tube. Similarly, the actual pressure to be used will depend on the length of the tube and the dimensions of the discharge nozzle. However, the governing requirement is that the helical course of the coolant jet must be maintained until it reaches the end of the tube.

• *EQUIPMENT FOR MAKING ULTRASONIC PICTURES VISIBLE*

A new principle has been proposed for rendering ultrasonic pictures visible as electron-optical images. The corresponding equipment comprises a tuned piezo-electric crystal and means for producing a potential picture on the back of the crystal by the ultrasonic wave-front modulated by the picture content. Electrons, rendered homogeneous by electron-optical means are then directed onto the back of the crystal by an electron gun, which consists of a source of electrons and an acceleration system. The electrons are reflected, braked, or absorbed on the quartz surface, which is provided with a very thin semi-conductive coating, by the potential image corresponding to the picture content. The reflected electrons are then driven onto a fluorescent screen, where they produce an electron picture, which constitutes an exact copy of the sound picture formed on the quartz. A sharp electron picture of an ultrasonic picture formed on the quartz is also produced after reflection of the electrons, independently of the reflecting potential field, i.e., independently of the potential of the individual electrodes of the electron-optical system. Enlargement of the reflected picture, not the picture sharpness, is dependent on the reflecting field, and this enlargement may be greatly influenced by the voltage applied. When highly driven potential differences of the electrodes are employed, this arrangement may therefore be termed an ultrasonic microscope. An additional increase in sensitivity may be achieved by employing a piezo-electric transformer in place of the piezo-electric crystal.

For further information on developments reviewed in THE BLUE PAGES, readers are invited to write to the Editor.

Machine Cut Gears

CAPACITY PRODUCTION FOR SPURS
AND HELICALS UP TO 15 FEET DIAMETER.

INTERNAL GEARS
SPUR GEARS
SINGLE HELICALS
DOUBLE HELICALS
BEVELS and MITRES
SPIRAL BEVELS and MITRES
RACKS and PINIONS
WORMS and WHEELS

Crofts

✱ WRITE FOR PUBLICATION No. 5519

CROFTS (ENGINEERS) LIMITED BRADFORD 3 ENGLAND

Tel: 65251 (20 lines) Grams: 'Crofters Bradford Telex' Telex 51-426

BRANCHES AT Belfast, Birmingham, Bristol, Cardiff, Dublin, Glasgow, Leeds, Liverpool, London, Manchester, Newcastle, Northampton, Nottingham, Sheffield, Stoke.

THE ENGINEERS' DIGEST
REVIEW OF WORLD ENGINEERING PROGRESS
VOL. XVIII No. 5 MAY, 1957

Surface Contacts with High Loading Pressures in Corrosive Atmospheres

By D. MÜLLER-HILLEBRAND. (From *Elektrotechnische Zeitschrift* (*E.T.Z.*), *Germany*, Edition " A ", Vol. 77, pp. 860–863, 2 illustrations.)

WHEN considering contacts with high loading pressures in corrosive atmospheres, it is necessary to distinguish between visible and electrically measurable corrosion. The formation, size, and number of current-transition points in surface contacts of oxide-free metals and graphites gradually covered with foreign layers have been determined in a previous experimental and theoretical investigation[1], in which the fraction of the loaded contact surface which is electrically conductive for a contact covered with a thin invisible layer of oxide was estimated. As an example, it was found that, for a copper contact subjected to a load of 100 kg, with an overlapping surface of 200 mm², and a very fine-ground surface finish, the load-carrying surface was effectively only about 4 mm², and the electrically conductive surface, made up of a large number of fine cracks in the oxide film, was of the order of 0·1 mm². There are, therefore, three different surfaces to be considered, i.e., (1) the overlap surface of contact blades, determined by the actual design ; (2) the load-carrying contact surface, which is mainly determined by the contact pressure, and by the surface condition and hardness of the metal ; and (3) the electrically conductive contact surface, which is essentially a function of the mechanical and electrical properties of the foreign layers and the base metal.

Although the electrically conductive surface is always small relative to the overlap surface technically required, the electrical resistance of contact arrangements subjected to heavy mechanical loads can be technically acceptable ; in other words, its resistance may be equal to or smaller than that of a contact blade with a length equal to that of the overlapping section.

As foreign layers are formed on open-type contacts accessible to air, an increase in contact resistance of blade-type connections can be measured when the contacts are closed after a period of storage. The rate of increase of this contact resistance has been investigated[1,2] and has been found to depend on a number of factors, e.g., initial treatment and hardness of the material, ambient temperature, and humidity. To obtain the required data in these investigations, measurements were made on contact blades of 15 × 3 mm, which were stored without special protection, and which were placed crosswise on each other for the test and subjected to a load of 250 kg. The results then indicated the period of exposure which could be assigned to each specimen, i.e., the time which it takes to reach the maximum still permissible value of contact resistance. Allowance must be made for a considerable amount of scatter in these results.

(1) D. MÜLLER-HILLEBRAND : " Flächenkontakte unter hoher Druckkraft " ; *Wissensch. Veröff. Siemens-Werke*, Vol. 20, 1941, pp. 85–103.
(2) D. MÜLLER-HILLEBRAND : " Aluminium als Leiter in Schaltgeräten " ; *E.T.Z.*, Vol. 61, 1940, pp. 1117–1122.

These tests under high loading pressures showed in particular that duration of the exposure could be increased considerably by means of the following treatments :—

(1) Application of a coating of soft, and to some extent corrosion-resistant, tin. Owing to the low hardness of tin, the two surfaces in contact flow into one another, causing a large number of ruptures in the foreign layer, so that, in spite of the much lower conductivity of tin relative to copper, the contact resistance has a low value.
(2) Roughening of the surface, resulting in high spots which subside under pressure and thus break up the foreign layer, so that metallic contact is obtained.
(3) The use of precious metals or metallic coatings.

For completeness, it may be mentioned that duration of exposure is also considerably increased when a coating of grease (e.g., vaseline) is applied.

The humidity of the ambient air has a considerable effect on contact resistance. This influence is particularly apparent in industrial installations exposed to air containing sulphur or chlorine, and protection against corrosion is necessary in such cases. It is not sufficiently borne in mind, however, that in dry air corrosive attack is very slow. Frequently, in plants where there is a danger of corrosion, fresh air is supplied by means of a fan, but this air is also substantially humid. It would therefore be preferable to have such installations exposed only to dry air, obtained from a drying plant, with hermetically sealed premises and a room temperature between 40 and 50°C. The conditions obtained would then be approximately the same as in a totally enclosed installation, in which (provided that sealing is satisfactory) corrosive attack is prevented to a considerable extent.

CONTACTS BETWEEN VARIOUS METALS

Contact corrosion between metals having different normal potentials in screwed connections takes place slowly in humid air. For reference, it may be noted that the normal potential of like metals is zero, and that such connections are good in moderately humid or even wet surroundings. Copper-to-iron connections produce a potential of 0·785 V and are usable in such surroundings, whereas copper to aluminium and aluminium to iron give higher values and can be used in moderately humid but not wet surroundings. These results agree with experience under service conditions. They apply also to alloys made from the metals considered, e.g., to brass and bronze as well as copper, and to various types of steel as well as iron, provided that the metals and their alloys are corrosion-resistant or corrosion-protected for the application considered.

For testing the suitability of connections for use in

salty and humid atmospheres, it is advisable for reliable results to spray the contacts about 1500 times with suitable salt-mist equipment. Bolted connections of aluminium and copper are not suitable in open-type installations or in plants with a chemically aggressive atmosphere (ships' installations being included in this category), since connections with these two materials can at most sustain about 1000 sprayings with mists containing common salt, before contact resistance reaches its limiting value. When this treatment is continued, contact resistance increases suddenly and the connection becomes technically useless. However, in normal premises for switchgear installations, contact between aluminium and copper over large contact surfaces does not require any special precautions.

Experimental Investigations

With open contacts in switchgear, fuse-boxes, etc., corrosive attack can have particularly severe effects. Even after a very short time, both copper and silver are covered with a visible foreign layer. To obtain data under open-contact conditions, additional tests were carried out. Copper blades of 15 × 3 mm, as previously mentioned, covered with various protective coatings, were suspended in a corrosive atmosphere, in different rooms in a sulphate plant (see below) the object being to determine the electrical suitability of coatings of nickel or chromium, as compared with silver coatings of various thicknesses. Optically, nickel and chromium are favourable, whereas silver immediately shows a dark tarnish. A further object was to determine whether a thick electrolytically deposited protective layer provides any advantages over a thinner layer. It is known that thin layers of, say, 5 microns in thickness tend to form a large number of pores, so that it is sometimes regarded as necessary to make the layer at least 40 microns thick, in order to ensure effective protection of the base metal.

The investigation was carried out in three rooms, i.e., in a fairly humid, ventilated room, in which a low-tension switching installation was accommodated (Room 1) ; in a wet room, in which water vapour was present, with air contaminated by bivalent sulphur compounds (Room 2) ; and in a room kept very wet with ample quantities of dripping water, the specimens being protected, however, against direct splashing, and with the air contaminated by bivalent and quadrivalent sulphur compounds and chlorine (Room 3).

The results obtained in Room 1 may be summarized as follows, the various coatings being classified as thin (5 to 6μ), fairly thick (17 to 20μ), thick (35 to 40μ), and very thick (about 80μ) :—

(1) Thin and fairly thick bright nickel plating became useless after 35 days, although bright in appearance, with some matte spots and a yellowish tinge.
(2) Thin and fairly thick dull nickel plating was still usable, with a voltage drop up to 3 mV at 100 A, after 35 days, but only the thin coatings were usable after 97 days, although their appearance was practically unchanged, being slightly dull or yellowish.
(3) Thin and fairly thick chromium plating became useless after 35 days, although of bright and practically unchanged appearance.
(4) Thin and fairly thick cadmium plating became useless after 35 days, and showed a uniform greyish-white appearance for the thin coatings, and a somewhat darker appearance for the thicker coatings.
(5) Thin and fairly thick bright silver plating was technically acceptable after 35 days but after 97 days, thin coatings proved superior to thick coatings ; the appearance was dull, brownish-yellow, or bluish.
(6) Very thin dip-tinning was technically acceptable after 35 and 97 days exposure, the appearance being a dull grey.
(7) Pickling proved to be useless after 35 days ; the appearance was brown, with green and violet inclusions.

Visible corrosive attack was least marked on chromium-plated, bright nickel-plated, and dull nickel-plated copper rails. Electrical assessment, however, differs from optical assessment in its results. The contact resistance of the chromium-plated and bright nickel-plated surfaces was high, the reasons being that (1) the resistivity of the protective coating of chromium is ten times, and of nickel four times, that of copper ; moreover, in the electrodeposited state resistivity is frequently appreciably higher than in the annealed and rolled condition. This applies particularly when non-metallic constituents are introduced by the electrodeposition process ; (2) the protective layer is considerably harder than the base copper. The hardness of electrodeposited layers depends on a large number of factors in the production process, and in most cases corresponds to that of work-hardened metals.

The thicker are the hard layers the less they will deform under mechanical load. Thus, the test results for Room 1 showed that only those dull nickel-plated specimens with a layer thickness of 5 to 6 microns exhibited a contact resistance of less than 30 micro-ohms after 35 days storage. In addition, bright silver plating gave a lower resistance with a thin layer than with a thick layer.

The fact that very soft dip-tinned surfaces showed the most favourable behaviour is understandable from the above explanation.

Importance, therefore, should be assigned to the mechanical (and not to the electrical) properties of the foreign layers and the metal from which they are generated. It may be said that contact resistance increases with increasing hardness of the protective metal ; with thickness of the protective metal, from a few microns upwards (when harder than the base metal) ; with thickness of the foreign layer (in a sulphur-containing atmosphere); and with ductility and adhesion strength of the foreign layer. The question as to which of these influences finally becomes predominant can be decided only experimentally.

On all the protective layers investigated, foreign layers were formed after short or long periods of time. Corrosion attack can be so pronounced that thin protective layers are destroyed, or the base metal is attacked through the pores in the layers. Consequently, as already mentioned, it has been suggested that the base metal should be covered by protective layers of, say, 40 microns in thickness. When this requirement is complied with, however, the formation of foreign layers becomes so considerable that the surface contacts become electrically useless. Technically usable contact connections have a purely metallic contact resistance which is independent of current intensity. Foreign layers play practically no part in the conduction of current, constricting and reducing the electrically conductive contact surfaces and reducing the number of transition points which provide a flow of current. With foreign layers of increasing thickness, the conductive cracks are of smaller size for a

(*Concluded on page 213*)

The Changes Produced in an Air Stream by Wire Gauze

By P. JONAS. (From *Czechoslovak Journal of Physics*, Vol. 7, No. 2, 1957, pp. 202–212, 11 illustrations.)

This paper gives the results of measurements of the resistance coefficients of five wire gauzes of varying mesh, and establishes the empirical dependence of the resistance coefficient on the velocity of the air stream and the porosity of the gauze. In addition, the reduction of steady disturbances and of turbulence by the gauze, for a large disturbance (30% of average velocity) and a large intensity of turbulence (up to 20%), was measured. The results confirm the validity of the relations of the theory of Taylor and Batchelor for disturbances and for intensities of turbulence of the given order of magnitude.

THE use of gauze is at present widespread as a means of equalizing velocity and reducing turbulent flow in wind-tunnels, and permits the construction of wide-angle diffusers, in which the gauze is located, in order to limit the separation of flow from the walls.

Of theoretical papers dealing with wire gauze, the most complete appears to be that of Taylor and Batchelor.[1] In the following, the results of measurements are compared with the results derived theoretically by Taylor and Batchelor for special assumptions, and show good agreement, even in more general cases.

Resistance Coefficient of Wire Gauze

In this investigation, use was made of wire gauze of dimensions d, l_1, and l_2, as shown in Fig. 1. In most cases, $l_1 = l_2$, so that the gauze may be considered to have a square mesh of side $l = (l_1 + l_2)/2$.

The porosity of the gauze is defined by a constant β, which is expressed by the ratio of the surface of the holes to the total surface of the gauze, so that

$$\beta = \left(1 - \frac{d}{l}\right)^2 \qquad .. \quad .. \quad (1)$$

The aerodynamic properties of the gauze are determined by two parameters, i.e., the resistance coefficient χ and the side-force parameter of deviation α in the direction of flow on the surface of the gauze.

In the case of the resistance coefficient χ, if it is assumed that the air stream, after passing perpendicularly through the gauze, has a velocity u and a density ρ, and that the upstream and downstream pressures are respectively p_1 and p_2, then

$$\chi = (p_1 - p_2)/\tfrac{1}{2}\rho u^2 \qquad .. \quad .. \quad .. \quad (2)$$

and the resistance coefficient χ is a function of velocity u and of the gauze constant β.

With regard to the side-force parameter of deviation α, if the air stream strikes the surface of the gauze at an angle Θ from the normal, and the stream leaving the gauze is at an angle Φ from the normal,

$$\alpha = \Phi/\Theta \qquad .. \quad .. \quad .. \quad (3)$$

From experiments, there is a finite limit for α, even with $\Theta = 0$. Measurements made by Dryden and Schubauer[2] show that, for small values of Θ and Φ, and for values of χ higher than 0·7, the following empirical relation holds:

$$\alpha = 1{\cdot}1/\sqrt{1+\chi} \qquad .. \quad .. \quad .. \quad (4)$$

The experimental arrangement used is shown schematically in Fig. 2, in which the test section containing at the point S the frame in which the gauzes are mounted is joined to the wide part of the tunnel and the entrance cone at the point A, the distance AS being 75 mm. In the walls of the entrance cone and test section are openings for measuring the static pressures p_0 and p_2 by means of micromanometers of the Prandtl and Fuess type. The dynamic pressure q is measured by a Prandtl tube of 3 mm diameter, located at the point B, the distance SB being 90 mm.

The tunnel constant k for a tunnel without a gauze was defined as

$$k = q/(p_0 - p_2) \qquad .. \quad .. \quad .. \quad (5)$$

For the wind-tunnel used, $k = 1$. For calculating the resistance coefficient χ from the measured values of pressures p_0, p_2, and q, the following relation can be derived:

$$\chi + 1 = (p_0 - p_2)/q \qquad .. \quad .. \quad (6)$$

Measurements were made of the resistance coefficients χ of five brass or bronze wire gauzes of the following dimensions and gauze constants:

Gauze No.	d [mm]	l [mm]	β
1	0·500	1·90	0·543
2	0·096	0·20	0·270
3	0·050	0·10	0·250
4	0·150	0·36	0·341
5	0·262	0·33	0·424

Analysis of the measurements show that the resistance coefficient χ is a function of the gauze constant β and the velocity u of the stream, and can be expressed as a good approximation in the form

$$\chi = F_1(\beta)\,\frac{1}{u} + F_2(\beta) \qquad .. \quad .. \quad (7)$$

The functions $F_1(\beta)$ and $F_2(\beta)$ must satisfy the condition

$$\lim_{\beta \to 0} F_1(\beta) = \infty \quad \text{or} \quad \lim_{\beta \to 0} F_2(\beta) = \infty$$

This condition includes the case when there is a non-porous plate in the tunnel, i.e., a gauze constant $\beta = 0$. The dynamic pressure behind the plate is zero; thus, the resistance coefficient according to eq. (2) should increase beyond all limits. Another apparent condition is that expressing the case when there is no gauze present, i.e., a gauze constant $\beta = 1$.

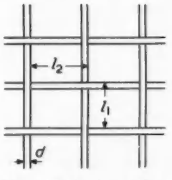


Fig. 1. Basic dimensions of wire gauze used.

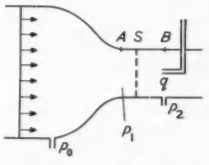


Fig. 2. Experimental arrangement for determining the resistance coefficient of wire gauze.

According to the analysis of Taylor and Davies[3], the functions $F_1(\beta)$ and $F_2(\beta)$ can be expected to depend on $1/\beta^2$. By plotting the results of measurements, however, it was found that, for $F_1(\beta)$, a dependence on $1/\beta^4$ was more satisfactory. For the resistance coefficients χ of the gauzes used, the dependence established by the author was

$$\chi = \left(\frac{0{\cdot}13}{\beta^4} - 0{\cdot}62\right)\frac{1}{u} + \left(\frac{0{\cdot}47}{\beta^2} - 0{\cdot}57\right) \quad .. \quad (8a)$$

where u is in m/sec.

The curves in Fig. 3 show the resistance coefficients χ of the five gauzes used as a function of velocity u, calculated in accordance with the empirical relations in eq. (8a), the actual measured values of χ being indicated by circles. On the whole, it can be seen that there is good agreement between the empirically calculated results and the measured results.

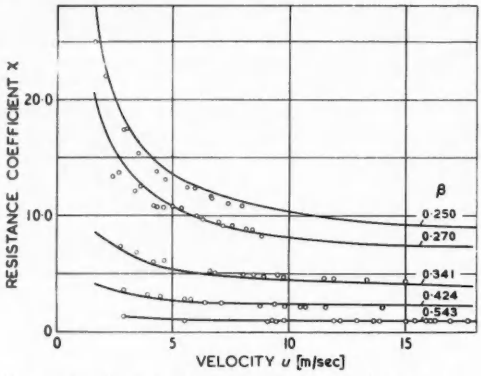


Fig. 3. Dependence of resistance coefficient χ on velocity of air flow u for various wire gauzes.

A similar analysis was effected of measurements of the resistance coefficient χ, compared with the results obtained by Taylor and Davies[3] and by Simmons and Cowdrey[4]. It was found that in both cases the results of these measurements can be expressed by a relation similar to that in eq. (8a), the resistance coefficient in the case of Taylor and Davies being

$$\chi = \left(\frac{0{\cdot}23}{\beta^4} - 1{\cdot}12\right)\frac{1}{u} + \left(\frac{0{\cdot}58}{\beta^2} - 0{\cdot}71\right) \quad .. \quad (8b)$$

and for Simmons and Cowdrey

$$\chi = 0{\cdot}233\left(\frac{1}{\beta^4} - 1\right)\frac{1}{u} + 0{\cdot}48\left(\frac{1}{\beta^2} - 1\right) \quad .. \quad (8c)$$

As before, good agreement between measured values and values calculated from the empirical relations in eqs. (8b) and (8c) was obtained.

From eqs. (8a), (8b), and (8c) it can be seen that the empirically determined functions $F_1(\beta)$ and $F_2(\beta)$ from the three different series of measurements differ from each other. It should be noted that the deviation of the author's measurements from those of Taylor and Davies and of Simmons and Cowdrey is greater than the difference between the measurements of these investigators; nevertheless, no deviations noted were such that eq. (7) could not be used with an approximation which is determined by the limited accuracy of measurement and the simplified assumptions regarding the actual geometric shape of the gauze. Furthermore, it should be pointed out that the measurement of the resistance coefficient χ is very difficult, as it is carried out at small air-stream velocities, the dynamic pressure being only a few millimetres w.g.; moreover, it requires determination of the gauze constant β with a high degree of accuracy and assumes perfect homogeneity of the gauze itself, while the presence of dust continually settling on the gauze, the experimental arrangement, the sensitivity of the measuring instruments, and the quality of the wire used in the gauze all have their effect. The possibility of measuring a fundamentally different resistance coefficient χ of a single large-mesh gauze, with a constant β greater than 0·5, is also mentioned by Simmons and Cowdrey[4].

In practice, the value of the resistance coefficient χ often does not need to be known with particular accuracy, in which case a satisfactory approximate relation is

$$\chi = 0{\cdot}15\left(\frac{1}{\beta^4} - 1\right)\frac{1}{u} + 0{\cdot}5\left(\frac{1}{\beta^2} - 1\right) \quad .. \quad (8d)$$

For small values of β, this relation approaches that given in eq. (8a), which is based on a larger number of measurements of gauzes with small β-values than those used for eqs. (8b) and (8c); for large values of β, eq. (8d) comes close to the relation in eq. (8c), which is based on a larger number of measurements of very porous gauzes.

The great importance of the exact determination of the gauze constant β can be appreciated if, for a given value of β with a certain error, the corresponding value of the resistance coefficient χ is determined from eqs. (8a), (8b), (8c), or (8d). Thus, for example, if there is an error of 5% in determining a value of β of 0·5, it will be found that the error in calculation of χ from eq. (8d), for a velocity u of 10 m/sec, will be 14·4%.

Reduction of Large Steady Disturbances by a Wire Gauze

If a co-ordinate system is introduced, in which the positive x-axis is in the direction of the normal to the surface of the gauze along the flow, and the y- and z-axes are located along the surface of the gauze, the longitudinal fluctuation of velocity is assumed by Taylor and Batchelor to be far upstream from the gauze in the special form $u = u_1 \cos py$, and far downstream from the gauze (along the stream) in the form $u = u_2 \cos py$. For attenuation in the longitudinal fluctuations of velocity, they obtain

$$u_2/u_1 = (1 + \alpha - \alpha\chi)/(1 + \alpha + \chi) \quad .. \quad .. \quad (9)$$

The attenuation in lateral fluctuations of velocity, i.e., v, w_1, v_2, and w_2, for a disturbance of the general form on the basis of eq. (3) and on the assumption of small disturbances, is, according to Taylor and Batchelor, given by the relation

$$v_2 = \alpha v_1 \quad \text{and} \quad w_2 = \alpha w_1 \quad .. \quad .. \quad (10)$$

For the purpose of carrying out measurements, the source of large disturbance was a cylinder, 20 mm in diameter, located in the air flow at the point A (Fig. 4). The deviations in mean velocity in the wake of the cylinder from the mean velocity of the undisturbed flow constituted a large disturbance which attained up to 30% of the velocity of the undisturbed flow. The disturbance was measured at the point B, first without a gauze and then with a gauze located at the point S for the same air-stream velocity.

Fig. 5 shows the dependence of u_2/u_1 on the resistance coefficient χ, the circles denoting the measured values and the solid curve the theoretical values derived from eq. (9). The dotted curves give, for purposes of comparison, the relations for the reduction of disturbance derived by Prandtl[5] and by Collar[6], Prandtl's relation being

$$u_2/u_1 = 1/(1 + \chi) \quad .. \quad .. \quad (11)$$

and Collar's relation

$$u_2/u_1 = (2 - \chi)/(2 + \chi) \quad .. \quad .. \quad (12)$$

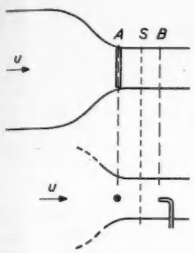


Fig. 4. Arrangement for measuring steady disturbances by means of a cylinder.

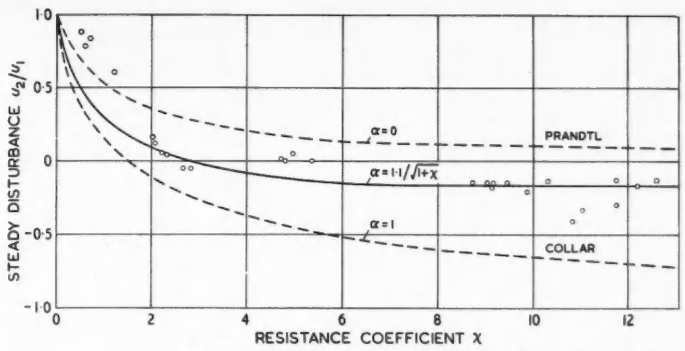


Fig. 5. Reduction of steady disturbance u/u_1 as a function of the resistance coefficient χ of wire gauze.

Taylor and Batchelor have proved that there are special cases of the more general relation given in eq. (9) which are derived from assumptions valid only in such cases. However, the measurements show that eq. (9) is quite valid, even for fairly large disturbances, the disturbance velocity upstream from the gauze being up to 30% of the velocity of the undisturbed flow. The wide variation of the measured results, compared with the theoretical values, for $\chi<0{\cdot}7$ is explained by the invalidity of eq. (4) below this limit. From the measurements and the theoretical analysis, it follows that a gauze with a resistance coefficient χ of about 2·8 reduces the disturbance almost completely.

The Effect of Wire Gauze on Turbulence

Taylor and Batchelor have extended their considerations of the attenuation of small steady disturbances to unsteady disturbances, i.e., turbulence. They do not consider turbulence in general, but assume it to be homogeneous far upstream and such that the r.m.s. velocity of fluctuation is small, compared with the mean flow velocity; furthermore, they neglect the effect of viscosity. Taylor and Batchelor have derived expressions[1] for the reduction in energy μ of longitudinal fluctuations, and for the reduction in energy ν of lateral fluctuations. In addition, they limit themselves to isotropic turbulence, and consider the three-dimensional energy spectrum function of the oncoming turbulence, obtaining the relations

$$\mu = \frac{(1+\alpha-\alpha\chi)^2+2\alpha^2}{(1+\alpha+\chi)^2-4} + \frac{(1+\alpha-\alpha\chi)^2-4\alpha^2}{(1+\alpha+\chi)^2-4} \times \frac{3}{2}(1-\eta^2)\left(1+\frac{\eta^2-\zeta^2}{2\eta}\log\frac{\eta-1}{\eta+1}\right) \quad .. \quad (13)$$

and

$$\nu = \alpha^2 + \tfrac{1}{2}[(1+\alpha-\alpha\chi)^2-(1+\alpha+\chi)^2\mu] \; .. \quad (14)$$

where $$\eta = \frac{(1+\alpha+\chi)^2}{(1+\alpha+\chi)^2-4}$$

and $$\zeta^2 = \frac{(1+\alpha-\alpha\chi)^2}{(1+\alpha-\alpha\chi)^2-4\alpha^2}$$

For measurements of the longitudinal component of the turbulence in the wake of a cylinder, the arrangement used was similar to that shown in Fig. 4. The measurements showed that the intensity of the longitudinal components of turbulence varies only slightly with distance downstream from the cylinder, provided that they are not taken too close to the cylinder.

The reduction in the total energy of the longitudinal component of turbulence is calculated from the intensities of the longitudinal components measured for the same mean velocity of the air stream behind the cylinder, first with gauze at the point S and then without the gauze.

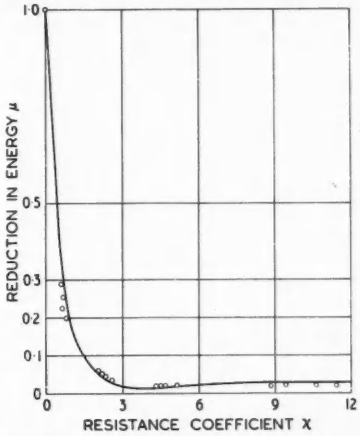


Fig. 6. Reduction in energy μ of longitudinal component of turbulence as a function of the resistance coefficient χ of wire gauze.

Fig. 6 shows a comparison of the measurements (indicated by circles) with the theoretical relation for the reduction of longitudinal components of turbulence from eq. (13). It will be noted that there is good agreement between the measured and theoretical values, even when the turbulence was neither small nor isotropic in the wake (the measured intensity of turbulence was up to 20% in front of the gauze), as was assumed by Taylor and Batchelor.

References

(1) G. I. Taylor and G. B. Batchelor : "The Effect of Wire Gauze on Small Disturbances in a Uniform Stream"; *Quart. Jour. Mech. and App. Math.*, Vol. II, 1949.

(2) H. L. Dryden and G. B. Schubauer : "The Use of Damping Screens for the Reduction of Wind-Tunnel Turbulence"; *Jour. Aero. Sci.*, Vol. 14, No. 4, 1947.

(3) G. I. Taylor and R. M. Davies : "The Aerodynamics of Porous Sheets"; *R. and M.* 2237, 1944.

(4) L. F. G. Simmons and C. F. Cowdrey : "Measurements of the Aerodynamic Forces Acting on Porous Screens"; *R. and M.* 2276, 1945.

(5) L. Prandtl : "The Attainment of a Steady Air Stream in Wind-Tunnels"; *N.A.C.A. Tech. Mem.*, No. 726, 1933.

(6 A. R. Collar : "The Effect of a Gauze on the Velocity Distribution in a Uniform Duct" *R. and M.* 1867, 1939.

U. S. A.

New Developments in Silicone-Rubber Compounds for Extruded Electrical Insulation

By M. G. Noble. (From *Wire and Wire Products*, Vol. 32, No. 2, February 1957, pp. 170, 172-175, 216-217, 6 illustrations.)

Silicone rubber is finding increasing acceptance as an insulation material. In this paper, after briefly summarizing major applications illustrating certain fields in which silicone rubber is currently active, details are given of recent developments in silicone-rubber technology and of some fundamental data on physical and electrical properties, based on a current test programme.

Although military applications, e.g., shipboard cable, ignition cable, and aircraft wire still account for the largest volume of extruded insulation, there can be no doubt that civilian applications are also increasing in number, despite the fact that the higher material cost of silicone rubber has been a deterrent in the extremely competitive commercial fields. Among other reasons for this trend towards silicone rubber are the fact that other materials may be unsuitable because of operating conditions ; that redesign may offset differences in material costs ; that its cost is lower than that of satisfactory alternative high-temperature insulating materials ; that compounds with improved properties have been developed ; that there is now a more widespread knowledge of its inherent properties ; and that its longer service life, improved performance, and reduced maintenance requirements justify the higher initial outlay.

The polymer is the most important factor in determining the overall performance of silicone-rubber compounds, and is responsible for such fundamental properties as heat resistance, low-temperature flexibility, corona and ozone resistance, etc. Recent developments have given rise to improvements in the basic polymers, as a result of changes in composition and/or polymerization and processing techniques. These new polymers have resulted in compounds possessing such qualities as reduced shrinkage during oven curing, reduced compression set when subjected to loads at elevated temperatures, and improved physical properties. In addition, they have made possible the development of conducting silicone-rubber compounds, have contributed improved handling qualities to the uncured silicone-rubber compound, have reduced oven-curing cycles, and have engendered new vulcanization techniques. Furthermore, these improvements have been obtained without any sacrifice of the fundamental characteristics possessed by silicone-rubber compounds in general.

Similarly, developments of new fillers have resulted in compounds with appreciably improved physical properties, providing significant increases in such important features as tensile strength, elongation, and tear strength. Outstanding improvements have also been obtained in electrical properties. Thus, the development of such fillers as fumed silica has resulted in a ten-fold increase in insulation resistance, coupled with lower dielectric-constant and power-factor values, while low water-absorption qualities have led to stability in electrical properties, even when these compounds have been subjected to prolonged immersion in water.

As a result of proper filler selection, heat resistance has been extended. Thus, compounds are now available which show very little change in physical properties after ageing at 150°C for six months, while flexibility can be maintained even after exposure for six months at temperatures as high as 210°C, or for shorter periods at 315°C. At the same time, new filler and polymer combinations have yielded compounds with greater strength in the uncured state, providing better handling qualities during freshening and extruding operations. Flow qualities have been improved and have permitted the extrusion of thin-walled insulation, while surface qualities are better, and the shelf stability of the uncured compound has been extended. However, in the overall field of processing qualities, it should be realized that there is room for still greater improvement.

With regard to the influence of vulcanizing agents, benzoyl peroxide has long been the main vulcanizing agent used with silicone-rubber compounds, and is an excellent curing agent for extrusion applications where the fabricated part is to be cured under steam pressure. However, recently developed curing agents, such as bis (2, 4-dichlorobenzoyl) peroxide, dicumyl peroxide, and ditertiary butyl peroxide, have made it possible to develop new and improved processing techniques. As a result, it is now possible to cure wire insulated with silicone rubber by the continuous hot-air process, even with heavy wall thicknesses. In addition, the curing of conducting carbon-black compounds has been made a practical proposition for production purposes, while a much-needed flexibility has been introduced into the processing of silicone rubber. It should, however, be made clear that, despite these various improvements, it has not as yet been found possible to incorporate all of them in a single compound. Hence, careful selection is still required to obtain the proper compound for a specific application.

Considerable data have been collected over the past few years on the fundamental properties of silicone rubber. The following data in this paper, representing the latest information collected on the subject, are based on tests carried out by the General Electric Laboratories in the U.S.A. on three compounds, designated SE-972, 81625, and 81686, the first of these consisting of SE-76 silicone gum with a diatomaceous-earth filler and benzoyl peroxide as the curing agent, the second SE-30 silicone gum with a filler of fumed silica and diatomaceous earth and benzoyl peroxide as the curing agent, and the third SE-33 silicone gum with a fumed-silica filler and bis (2, 4-dichlorobenzoyl) peroxide as the curing agent.

Of these three compounds, SE-76 and SE-30 are methyl silicone polymers, the major difference being that compounds based on SE-30 have lower shrinkage characteristics than those based on SE-76. The General Electric SE-33 silicone gum is a low-shrinkage methyl silicone containing a small amount of unsaturation.

Tests on Physical Properties

As a result of new gum and filler combinations, substantial improvements in such typical properties as elongation, tensile strength, and tear strength have been achieved, as shown in Tables I, II, and III. In fact, compounds are now available which can be cured to give tensile strengths of 1200 to 1500 psi, elongations of 400 to 600%, and tear strengths of 150 to 200 lb/in.

It should be noted that physical properties are a function of curing temperature and time. The greatest

TABLE I: PHYSICAL PROPERTIES AFTER CURING FOR 1 HR AT 150°C.

	SE-972	81625	81686
Durometer	65	60	65
Elongation [%]	120	200	500
Tensile strength [psi]	650	900	1400
Tear strength [lb/in.]	40	70	200

TABLE II: PHYSICAL PROPERTIES AFTER CURING FOR 24 HR AT 150°C.

	SE-972	81625	81686
Durometer	70	60	70
Elongation [%]	100	200	450
Tensile strength [psi]	750	900	1400
Tear strength [lb/in.]	45	70	165

TABLE III: PHYSICAL PROPERTIES AFTER CURING FOR 24 HR AT 250°C.

	SE-972	81625	81686
Durometer	75	65	80
Elongation [%]	75	125	220
Tensile strength [psi]	800	750	900
Tear strength [lb/in.]	50	70	110

improvements have been achieved in compounds when they have been cured at relatively low oven temperatures. These new compounds show decreases in tensile strength, elongation, and tear strength with increasing oven temperature and curing times. However, even after 24 hr at 250°C, it has been found that benefits have been obtained in the form of higher retained values.

The question of the correct oven cure is one which must be related to the final application. As a rule of thumb, it is wise to cure the wire at a temperature equal to or slightly higher than the maximum temperature to which it will be exposed in service. With the exception of highly specialized applications, a short exposure time (1 to 6 hr) is all that is required. In many wire applications, the insulation can complete its cure while actually in service. In such cases, the oven cure may be eliminated or confined to relatively low temperatures (up to 150°C), resulting in optimum physical properties.

Effect of High-Temperature Oven Ageing:—

With regard to the question of maximum continuous service temperatures for silicone rubber, tests are in progress at the General Electric Laboratories to determine the effects of long-time exposure to 150 to 210°C on physical properties. These tests have been under way for more than six months, and will be continued for several years, or longer, if necessary. The results to date no materials 81625 and 81686 are given in Table IV.

TABLE IV: EFFECTS OF OVEN AGEING AT 150°C AND 210°C.

	81625		81686	
	Elongation [%]	Tensile strength [psi]	Elongation [%]	Tensile strength [psi]
1 day at 150°C	175	900	450	1400
1 month at 150°C	160	900	275	1200
2 months at 150°C	150	900	275	1150
4 months at 150°C	150	850	still in progress	
6 months at 150°C	150	850	still in progress	
1 day at 210°C	150	900	325	1200
1 month at 210°C	130	900	200	950
2 months at 210°C	130	950	125	850
4 months at 210°C	100	1000	still in progress	
6 months at 210°C	80	1100	still in progress	

TABLE V: ELECTRICAL PROPERTIES AFTER CURING FOR 24 HR AT 150°C.

	SE-972	81625	81686
Volume resistivity [ohm-cm]	5×10^{14}	1×10^{15}	1×10^{16}
Electrical strength [V/mil]	500	500	500
Dielectric constant (60 cps)	3·4	3·1	3·0
Power factor (60 cps) [%]	0·8)	0·35	0·15

With both materials, flexibility was satisfactory, but the results for four months and six months, in the case of material 81686, are not yet available, as this product is new and has only recently been incorporated in the test programme. However, the ageing data obtained over two months with this compound indicate that it will not be equal in overall ageing properties to material 81625, which has demonstrated excellent stability at 150°C. As was only to be expected, depreciation in properties has been accelerated by oven ageing at 210°C; however, appreciable elongation and very good flexibility were still retained even after ageing for six months.

TESTS ON ELECTRICAL PROPERTIES

In addition to improvements in physical properties, particularly in the case of material 81686, improvements in electrical properties have also been noted. The fundamental electrical properties of the three test compounds after curing for 24 hr at 150°C are listed in Table V, and it will be observed that volume resistivity has increased appreciably, while improvements in dielectric constant and power factor are also noteworthy.

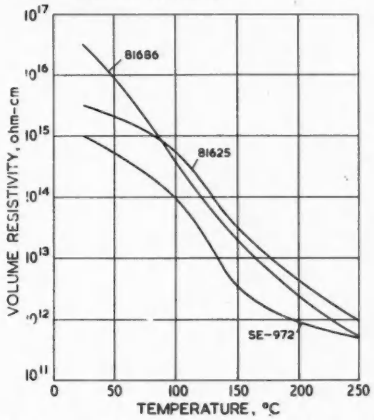


Fig. 1. **Volume resistivity as a function of ambient temperature.**

The influence of ambient temperature on volume resistivity has been covered in several previous papers, and it has been established that the volume resistivity of silicone-rubber compounds varies inversely with ambient temperature, as is typical of other insulating compounds. The same trend has been observed with these newer formulations, the volume resistivity of which, as shown in Fig. 1, decreases with increasing temperature; insulating qualities are, however, still retained, even at 250°C, volume resistivity for the three test compounds ranging between about 5×10^{11} and 1×10^{12} ohm-cm at this temperature.

The influence of prolonged immersion in water at room temperature (23°C) and at 70°C on dielectric constant is shown in Fig. 2, and on power factor in Fig. 3. It will be seen that all three compounds show very good stability after immersion for 60 days in water both at 23° and 70°C. These tests are being continued, to determine the effects of longer immersion times.

The influence of thickness on electrical strength must always be taken into consideration. In this connection, tests have been instituted on a number of compounds, including the three test compounds, test thicknesses

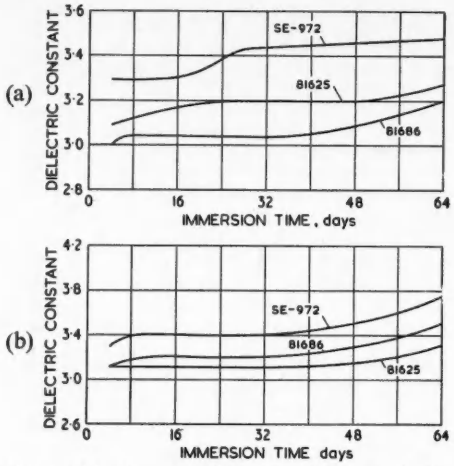


Fig. 2. Dielectric constant (60 cps) as a function of duration of immersion in water (a) at room temperature, and (b) at 70°C.

varying between 20 and 500 mils. As a result, it is concluded that the electrical strength in volts per mil decreases with thickness independently of the silicone-rubber formulation. The decrease in electrical strength with increasing thickness, for materials SE-972, 81625, and 81686, can be plotted as a smooth curve (Fig. 4).

Voltage Endurance Tests:—

Although it is recognized that the ozone resistance of silicone rubber at normal temperatures is excellent, the question may arise as to the effects of high ambient temperature on ozone resistance. As it was considered that an answer to this question is extremely important, a test programme was initiated in the G.E. Laboratories, and, although this programme is not yet completed, some preliminary results are of interest.

The test specimens used are short lengths of insulated wire, comprising a No. 20 a.w.g. (about 22 s.w.g.) copper conductor insulated to a nominal diameter of 0·120 in. with a number of different compounds. The samples are wrapped helically around a 0·295-in. mandrel, so as to subject the outer surface of the insulation to an elongation of approximately 25%. The wrapped samples are then inserted into stainless-steel tubing of 0·625 in. i.d., and the supporting mandrels are removed. Steel tubing was selected because preliminary tests with 40-mesh screen electrodes resulted in too rapid a removal of degradation products by the air circulating in the oven. Ceramic bushings are inserted into the ends of the tubing to prevent edge breakdown, and lead lengths of 5 in. are used to avoid flash-over at elevated temperatures. The test assemblies are then placed in a high-temperature oven and subjected to a potential of 10 kV, this stress being selected because it represented about 50% of the average breakdown voltage for the test specimens.

Up to the present, these samples have been under test for 100 hr at a temperature of 250°C, without any signs of corona erosion or stress-cracking, the only noticeable change being a progressive hardening of the silicone-rubber insulation. Relative resistance to hardening is being studied by means of ultimate elongation measurements. This property was chosen because it was felt that there is a correlation between elongation and stress-cracking under flexing conditions. A value of 75% elongation was selected as the end-point for indicating failure. Only one compound, i.e., SE-972, has become so hard as to break down electrically. This compound has relatively poor heat-ageing qualities, and heat ageing is accelerated by these test conditions. Materials 81625 and 81686 have approached the 75% elongation after exposure for 100 hr, so that these tests have been discontinued. The next step in the programme calls for determination of endurance life at 200°C. When these points have been established for the various compounds, consideration will be given to obtaining similar data at lower temperatures.

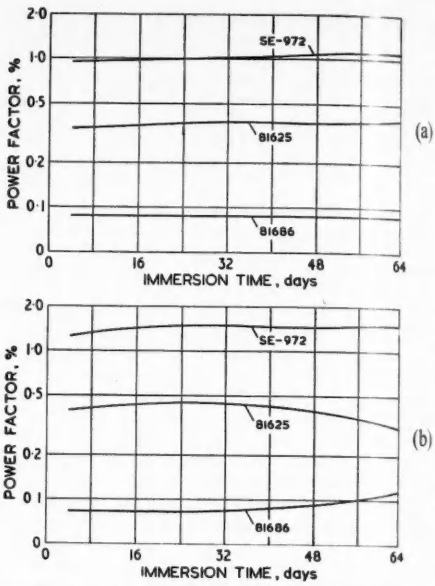


Fig. 3. Power factor (60 cps) as a function of duration of immersion in water (a) at room temperature, and (b) at 70°C.

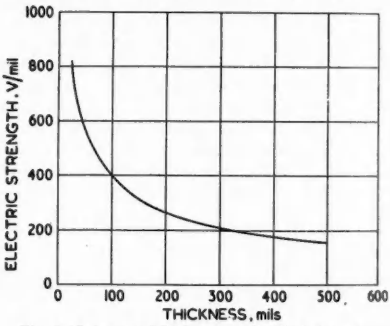


Fig. 4. Influence of thickness on electrical strength.

These test conditions are so severe that organic-rubber insulation would fail in a few minutes, even when tested at room temperature. Consequently, the limited data so far available tend to indicate that the ozone resistance of silicone rubber at temperatures as high as 250°C is still very good. It is, however, recognized that moisture, surface contamination, degree of stress, and other variables which might be encountered in service and which are not taken into account in this test programme might influence the performance of a cable under a specified set of conditions.

Dynamic Tooth Forces

By G. NIEMANN and H. RETTIG. (From *VDI Zeitschrift*, Vol. 99, No. 3, January 21, 1957, pp. 89-96, and No. 4, February 1, 1957, pp. 131-137, 54 illustrations.)

IN the course of gear design, difficulties have arisen in the application of the results of measurements on existing gears and of gear tests to new conditions, owing to doubts about the appropriate dynamic incremental load. Experience shows that for many cases the existing methods of calculation [1–5] do not apply.

The object of this research, therefore, was to measure, at the teeth of rotating and loaded steel gears, the actual tooth forces and in particular their dependence on important variables. The effects determined, i.e., those of pitch-line velocity, tooth error, static load, tooth spring constant, mass, etc., form the basis of a closer prediction of the dynamic increment load.

TEST RIG AND MEASURING TECHNIQUE

The test rig (Figs. 1 and 2) consists of an enclosed gearbox in which the test and drive gears are carried on

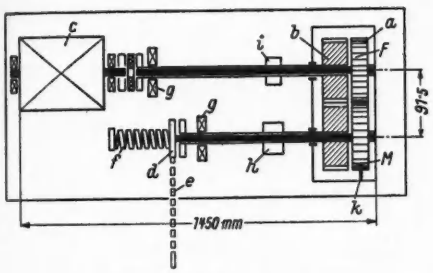


Fig. 1. Gear-loading test rig.
(*a*) Test gears; (*b*) transmission gears; (*c*) drive motor; (*d*) loading coupling; (*e*) loading lever; (*f*) additional shaft spring; (*g*) bearing; (*h*) torque meter; (*i*) synchronization pick-up; (*k*) tooth-position pick-up; (*F*) defective gear; (*M*) measuring gear.

solid or hollow shafts. With the rig stationary, a known torque, applied by means of a lever and weights, is locked into the system at a loading coupling, this torque being the static torque on the gears. The trunnion-mounted driving motor is fed from a Ward-Leonard set and is steplessly variable between 0 and 2500 rpm. To permit alteration of the spring constant of the shafts, interchangeable coil springs *f* (Fig. 1) are fitted, and for alterations of polar moment additional masses *f* and *g* (Fig. 2) can be added to the test gears.

To measure tooth deflection, an inductive measuring technique was chosen because the pick-ups used are very small, easily calibrated, free from friction, and exert no restraints. In addition, their sensitivity is sufficiently high for the evaluation of small tooth loads, they are only slightly temperature- and oil-sensitive, and their mechanical resonant frequency is high enough for vibrations as high as 4000 cps to be measurable with a bridge carrier frequency of 20 kcs.

For static measurements, the pick-up shown in Fig. 3 was used, the gauge length being 10 mm. For dynamic measurements, a special tooth-deflection measuring device, also working inductively, was developed (Fig. 4), which was free from the effects of friction, tilting, and temperature, *a* being the armature attached to the tooth tip. Both pick-ups have an armature pin, attached to the tooth tip, which moves in the magnetic field of two coils. The coils form the arms of a measuring bridge, energized by a crystal oscillator, and the system transforms the tooth movement to be measured into an electrical quantity. The calibration curves for the system are linear for a displacement of about $\pm$ 35 μ. The inductance variations at the pick-up are displayed on a cathode-ray or a mirror oscillograph[6].

To obtain interference-free and reproducible deflection diagrams, the pick-up output must be transmitted without disturbance from the rotating gear to the measuring bridge.[7] For this purpose, a large number of contact pairs was tried, and mercury in chromium-plated steel grooves with rotating copper-amalgam brushes was found to be good, as also were silver slip-rings with silver-graphite brushes. Tooth marker signals and triggering pulses for additional time and position markers on the oscillograph record were obtained inductively[8].

RESULTS OF STATIC TOOTH-DEFLECTION MEASUREMENTS

To interpret dynamic measurements on a tooth of a rotating gear in terms of load, the relation between load and tooth deflection as a function of tooth position must be known. Accordingly, the elastic tooth deflection w of a pair of gears for constant static normal tooth load P was measured for numerous points along the path of contact (in increments of 0·5 deg. of tooth rotation) with the strain gauge shown in Fig. 3. The deflection w was also calculated as a check from an approximate equation derived by Weber[9].

The results are presented in Fig. 5 as the elastic deflection w_{tot} of the point of application of the load P as a function of mean contact length, or mean angle of gear rotation, in both directions. For the theoretical values, the elastic Hertzian compression of the tooth flanks was also taken into account.

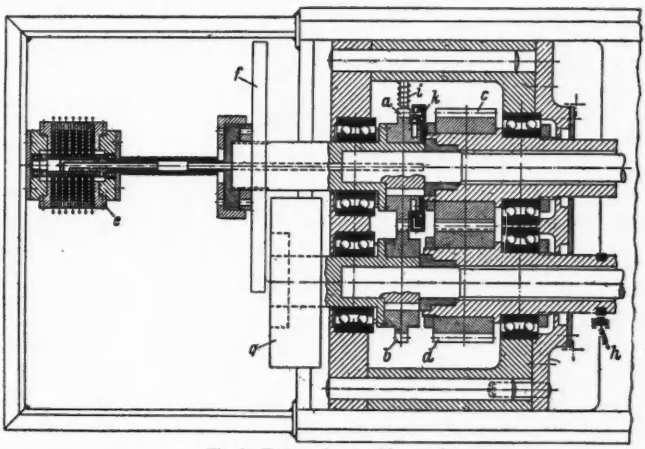


Fig. 2. Test gearbox used in test rig.
(*a*) Measuring gear; (*b*) meshing gear; (*c*), (*d*) transmission gears; (*e*) slip-rings; (*f*), (*g*) additional gear masses; (*h*) synchronization pick-up; (*i*) tooth-position pick-up; (*k*) tooth-displacement pick-up.

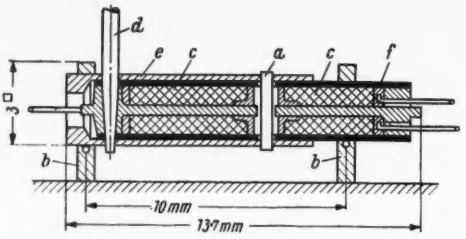


Fig. 3. Inductive strain gauge for measurement of static tooth deflection.
(*a*) Armature; (*b*) mountings (spot-welded to testpiece); (*c*) differential coils; (*d*) pin for zero setting; (*e*) non-magnetic case; (*f*) iron tube.

It can be seen that, in the region of single tooth contact, there is good agreement between measurement and calculation. In the zone of double tooth contact the measured rise or fall of tooth deflection is less steep than that calculated[2]. Further static measurements on tooth pairs with positive and negative base-pitch errors show that, as expected, a projecting incorrect tooth flank carries the load by itself along a greater part of the contact path. Consequently, the load is applied at a higher level on the tooth which undergoes greater deflection (larger bending moment). At the same time, the load on the preceding and following teeth is reduced. If the flank is too low, the opposite effects occur. Moreover, it has been found that, with incorrect tooth flanks, the transfer of load from one tooth to the next is more sudden than for error-free teeth.

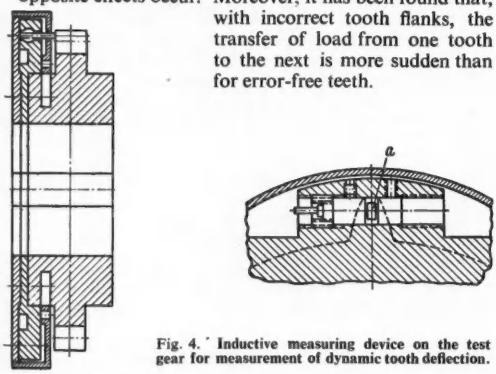


Fig. 4. Inductive measuring device on the test gear for measurement of dynamic tooth deflection.

With increasing positive tooth error, the range in which the defective tooth carries the load has been found to extend still further, so that, say, with a pitch error f_e of 160 μ, the actual contact ratio of the tooth becomes $\varepsilon_w = 2{\cdot}08$, whilst the theoretical contact ratio ε (with $f_e = 0$ and $P = 0$) is only 1·57; in the same way the value of ε_w of the preceding and following teeth is reduced. For tooth flanks with negative errors, ε_w is reduced in the same way as above for preceding and following teeth, even in some cases to the extent of complete exclusion of the tooth from contact.

The effect of tooth load P (expressed in kg per cm of tooth width) on the variation of tooth deflection w_{tot} and on ε_w is shown in Fig. 6, in which each scale division on the abscissæ corresponds to 2 deg. of rotation of the measuring wheel. With increasing load ε_w increases, e.g., from 1·65 for zero load to 2·12 for a static load P of 1885 kg/cm. With increasing load P (increasing ε_w), the beginning of single tooth contact is displaced, so that the maximum leverage and hence the ratio w/P become smaller.

Based on the present work, the following empirical expression has been established for the true contact ratio ε_w of the incorrect tooth flank:

$$\varepsilon_w \simeq \varepsilon + \frac{0{\cdot}134}{\sqrt{t_e}} \times \sqrt{P/\varepsilon c + f_e} \quad .. \quad .. \quad (1)$$

where P = specific normal tooth load [kg/cm]; f_e = base pitch error [μ]; c = tooth spring constant per cm tooth width = 10·8 kg/cm μ for tests with 20-deg. standard teeth; ε = theoretical contact ratio for $f_e = 0$ and $P = 0$; and t_e = base pitch [mm].

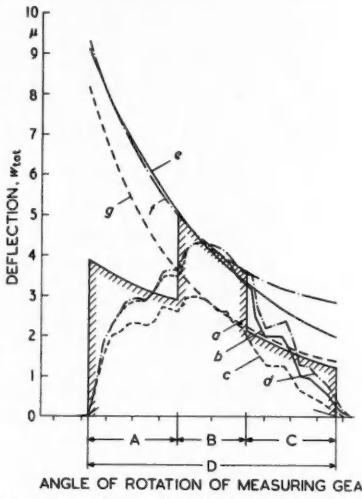


Fig. 5. Measured and theoretical tooth deflection w_{tot} as a function of contact path and angle of rotation, with a static load P of 143 kg and a pitch error f_e of less than 5μ.
Each scale division on the abscissa represents 2 deg.
(A), (C) Theoretical double tooth contact.
(B) Theoretical single tooth contact.
(C) Theoretical total contact length.
(*a*) Estimated tooth deflection at the point of application of the strain gauge, taking into account the load distribution.
(*b*) Measured tooth deflection at the gauge.
(*c*) Tooth deflection at the point of contact, without Hertzian compression.
(*d*) Tooth deflection at the point of contact, with Hertzian compression.
(*e*) Estimated tooth deflection at the point ot contact, with Hertzian compression, for a constant load P on the measuring tooth.
(*f*) Estimated tooth deflection at the point of application of the strain gauge, without taking into account load distribution, for a constant load P on the measuring tooth.
(*g*) Estimated tooth deflection at the point of contact, without Hertzian compression, for a constant load P on the measuring tooth.
Test gears:—30 teeth; 20-deg. pressure angle; 3-mm module; addendum modification factor = 0·2615.

The increase ($\varepsilon_w - \varepsilon$) of the contact ratio is at the same time a measure of the premature contact of the tip of the unloaded following tooth (tip interference). From this, the flank relief k needed to avoid interference can be calculated as

$$k = P/\varepsilon c + f_e \quad .. \quad .. \quad .. \quad (2)$$

Variation of Tooth Errors with Running Time

During the preliminary work, it became evident that tooth error did not remain constant. Special tests were therefore made to determine how the error varied with running time. Fig. 7 shows how the true contact ratio ε_w decreases with the number of tooth engagements. This is consequent on the decrease in tooth error arising from sliding wear and impact at the initiation of contact of the incorrect tooth. A steady value is reached after about four to five million load cycles. The final reduction

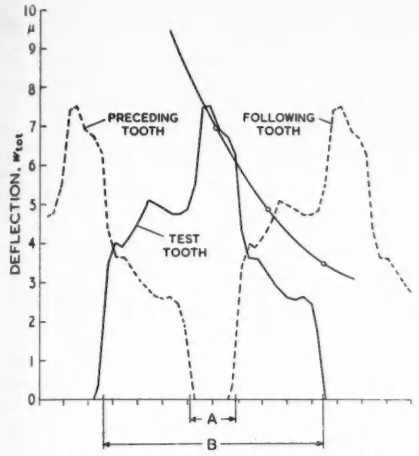


Fig. 6a. $P = 196$ kg.

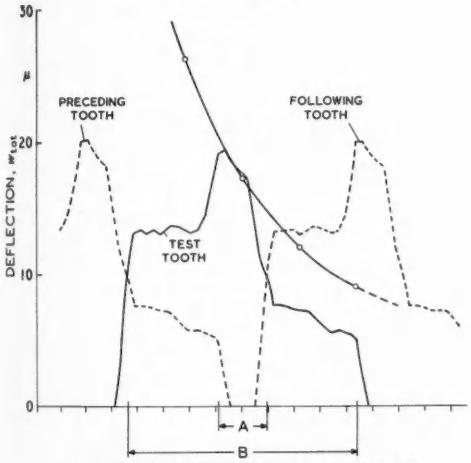


Fig. 6b. $P = 503$ kg.

δf_e in the initial error f_e is considerably greater for large tooth errors than for small errors. For hardened teeth the residual error is about $f_{eR} < f_e^{2/3}$, depending on the load. Several spot tests were also made with a hardened defective gear meshing with a grey cast-iron gear. However, the reduction in error was in this case much smaller, so that it appears that additional tests with different pairs of material are necessary.

The wear[10] along the incorrect tooth flank and the mating flank of hardened gears after various running times is shown in Fig. 8.

Results of Dynamic Tooth-Deflection Measurements

For measurements on loaded rotating tooth pairs the directions of rotation were so chosen so that the initiation of contact was at the tip of the measuring tooth and at the root of the incorrect tooth. The deflections at the pick-up during the load cycle were recorded by an oscillograph with respect to time at each load for a range of speeds of about 50 to 2000 rpm. The same tests were run with additional rotating masses, with different tooth errors,

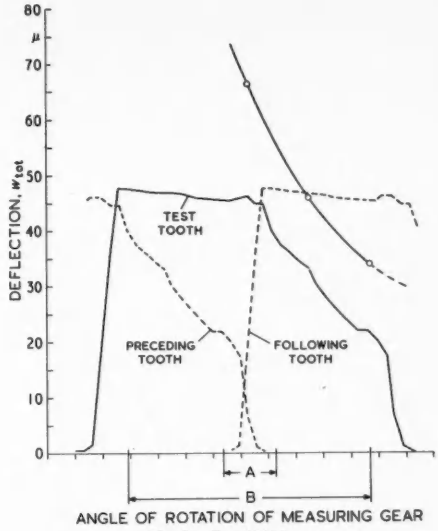


Fig. 6c. $P = 1885$ kg.

Fig. 6. Measured tooth deflections w_{tot} of preceding tooth, test tooth, and following tooth, with various loads P and a pitch error f less than 5μ. (A) Single tooth contact. (B) Theoretical total contact length.

and various tooth forms (different pressure angles).

The results of oscillographic records show that the way in which the tooth deflection changes in these records corresponds in general to a damped forced vibration, excited at the tooth frequency by impacts at the start of tooth contact, and in other cases to a damped natural vibration of frequency ν_E arising from the forced vibration[11]. The natural vibrations and their amplitudes become more evident as the load decreases and the tooth error and gear mass increase, whilst with increasing load and smaller error the natural vibrations tend to disappear.

In the deflection records with prominent natural frequencies the vibration frequency ν_E for tests on teeth with a nominal pressure angle of 20 deg., in normal gear-wheels, was about 2400 to 3000 cps and with additional

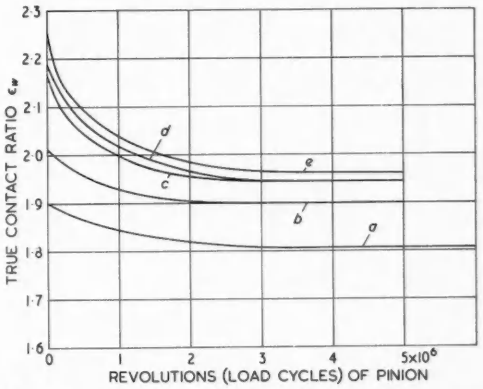


Fig. 7. Reduction of true contact ratio ε_W of incorrect tooth flanks with increasing running time, for different base-pitch errors f_e.
Theoretical contact ratio ε before test = 1·65. Hardened gears (60 Rockwell); load $P = 503$ kg/cm.
(*a*) $f_e \leq 5$; $n = 1450$ rpm. (*c*) $f_e \leq 120$; $n = 1450$ rpm.
(*b*) $f_e \leq 60$; $n = 1450$ rpm. (*d*) $f_e \leq 120$; $n = 2900$ rpm.
(*e*) $f_e \leq 160$; $n = 1450$ rpm.

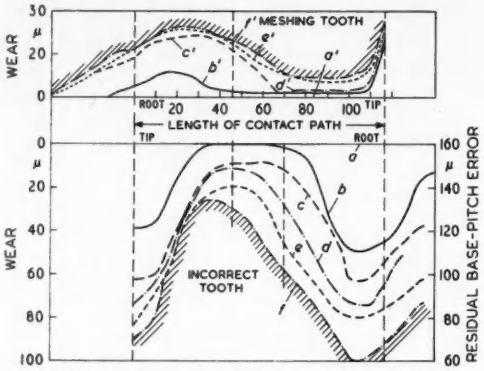


Fig. 8. Variation of wear along the flank of the incorrect tooth and the flank of the meshing tooth after various running times.
Base-pitch error f on one tooth = 160 μ. n = 1450 rpm. Hardened gears (60 Rockwell); load P = 503 kg/cm.
(*a*), (*a'*) Condition before running. (*d*), (*d'*) After 14 hr.
(*b*), (*b'*) After 2 hr. (*e*), (*e'*) After 24 hr.
(*c*), (*c'*) After 8 hr. (*f*), (*f'*) After 37 hr.

masses about 240 to 300 cps. The natural frequencies of the torsional system of gear masses and tooth elasticity are of the same order, so that the frequencies ν_E deter-

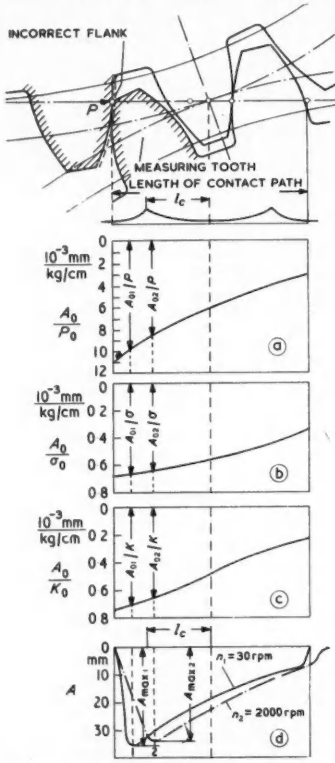


Fig. 9. Diagrams for the determination of tooth load P, root stress σ, and contact pressure K of the measuring tooth from the amplitude A of the oscillographic records, with the aid of a tooth deflection A_0 for a constant load P on each tooth.
The position of the pitch point relative to the tooth-position marker on the oscillographic records is given by l_c. The horizontal line of contact is the abscissa in diagrams (*a*), (*b*), and (*c*). The test gears are the same as in Fig. 5.

mined from the deflection records are to be regarded as vibrations of this system.

A change in the curve of tooth deflection can also be detected by the gear noise. A purer note corresponds to a simpler form of the record and a hammering or rattling noise of the tooth flanks to a premature return of the deflection to zero, followed again by a rise[12].

For the calculation of tooth load, root stress, and contact pressure from the tooth deflection A, the following quantities were evaluated for every tooth form tested, these being expressed as ratios plotted against the appropriate contact point along the path of contact (Fig. 9).

(1) The tooth deflection amplitude A_0 [mm] for constant tooth load P_0 [kg/cm]. The ratio A_0/P_0 is shown in Fig. 9a.

(2) The tooth root stress $\sigma_0 = P_0\,(q/m)\cos\alpha$ [kg/mm²] of the measuring tooth[3], the parameter[4] q corresponding to the appropriate tooth position. Fig. 9b shows the ratio $A_0/\sigma_0 = (A_0/P_0)\,(m/q)\cos\alpha$ where m = module [mm].

(3) The contact pressure $K_0 = P_0/2\varphi$ [kg/mm²] on the tooth flank[13], where φ is the effective radius of curvature at the point of contact. Fig. 9c shows the ratio $A_0/K_0 = (A_0/P_0)\,2\varphi$.

For each value A on the tooth-deflection record (e.g., A_{max} in Fig. 9d, the appropriate tooth load follows from these values by means of the equation

$$P = \frac{A}{A_0/P_0}\ \text{[kg/cm]} \qquad .. \quad .. \quad (3)$$

the stress σ from

$$\sigma = \frac{A}{A_0/\sigma_0}\ \text{[kg/mm²]} \qquad .. \quad .. \quad (4)$$

and the contact pressure on the tooth flank from

$$K = \frac{A}{A_0/K_0}\ \text{[kg/mm²]} \qquad .. \quad .. \quad (5)$$

It should be noted that, as a result, the farther to the right that A occurs on the record, the larger is the value of P, σ, and K given by a constant value of A. Care was therefore taken during the interpretation of the records to use those values of A which gave maxima for P, σ, and K.

(To be concluded)

REFERENCES

(1) E. BUCKINGHAM and C. OLAH : "Stirnräder mit geraden Zähnen"; Berlin, 1932.
(2) E. BUCKINGHAM : "Analytical Mechanics of Gears"; New York, 1949.
(3) *Hütte*, Vol. IIA, 28th. Ed., Berlin, 1954, pp. 175–176.
(4) W. A. TUPLIN : "Dynamic Loads on Gear Teeth"; *Machine Design*, Vol. 25, 1953, pp. 203–211.
(5) J. CAPELLE and J. BERTHOUD : "Étude des surcharges dynamiques dans les engrenages. *Bull. Soc. d'Études de l'Ind. de l'Engrenage*, No. 12, 1954.
(6) P. M. PFLIER : "Elektrische Messungen mechanischer Grössen"; Berlin/Heidelberg/Göttingen, 1948.
(7) G. VIEHMANN and H. FLEISSNER : "Schleifringe für Messzwecke mit niedrigen Kontaktwiderstand." *ATM Blatt*, No. 178, November 1950.
(8) BECKER-DÖRING : "Ferromagnetismus"; Berlin, 1939, p. 242 *et seq.*
(9) C. WEBER and K. BANASCHEK : "Formänderung und Profilrücknahme bei gerad- und schrägverzahnten Rädern"; Schriftenreihe Antriebstechnik, No. 2, Braunschweig, 1953.
(10) K. BURGER : Beiträge zur Messung von Stirnrädern mit geraden Evolventenzähnen"; Diss. Tech. Hochschule Dresden, 1935.
(11) K. KLOTTER : "Technische Schwingungslehre"; Berlin/Göttingen/Heidelberg, 1951.
(12) G. NIEMANN and H. GLAUBITZ : "Zahnfussfestigkeit geradverzahnter Stirnräder aus Stahl"; *Z.VDI*, Vol. 92, 1950, pp. 923–932.
(13) G. NIEMANN and H. GLAUBITZ : "Zahnflankenfestigkeit geradverzahnter Stirnräder aus Stahl"; *Z.VDI*, Vol. 93, 1951 pp. 121–126.

Accelerated Fatigue Testing of Plastics

By L. S. LAZAR. (From *ASTM Bulletin*, No. 220, February 1957, pp. 67–72, 16 illustrations.)

WHEN considering the potential applications of plastics, a serious problem is that of changes in their strength with time. A material may, for instance, fracture, sometimes catastrophically, under an alternating stress of only 25% of its ultimate strength after being subjected to these vibrational stresses for long periods. Fatigue, therefore, often determines the life of a plastic material in various applications.

The classical Wöhler method of determining fatigue involves stressing a number of specimens at various constant alternating stresses to failure or to an arbitrarily chosen number of stress cycles, i.e., the *S-N* diagram. Such data are usually highly scattered, and the *S-N* plot involves the problem of treating samples which fracture, together with those which endure the arbitrarily chosen number of cycles. These phenomena often occur at the same stress level. This means of interpreting fatigue requires rather extensive statistical analysis and is extremely time-consuming.

In 1948 Prot[1] reported a new accelerated technique for predicting fatigue limits. This method, the Prot progressive loading method, has been appraised by many investigators[2–6] to establish its reliability in predicting the fatigue limits of metals under rotating-beam fatigue conditions, and the work described in this paper is an appraisal of the validity of this accelerated method, using plastics under rotating and non-rotating fatigue conditions.

In the application of the Prot method, a low stress is placed upon the sample initially, and this stress is steadily increased during the test until failure occurs. While the applied stress is below the endurance limit of the material, no fatigue damage will occur. Fatigue will take place only when the applied stress equals or exceeds the endurance limit, a feature of the Prot technique being that no prior knowledge of the endurance limit is required.

Extruded polymethyl methacrylate and polystyrene were chosen as the first materials to be studied, since they are not only simple polymer systems but also offer the advantage of ease of machining and handling. They are thermoplastic materials which are non-crystalline and, after machining and polishing, offer a practically scratch-free surface. Since they are transparent, the observation of cracks as they form in the process of fatigue is facilitated.

Since highly crystalline nylon is used in so many applications where fatigue is the life-determining property, it was chosen as the third material. It is also the first small step taken in going from simple non-crystalline polymers to more complex systems. The nylon used was commercial rod stock.

The investigation was limited to ⅛-in. round specimens, machined radially to provide a minimum thickness at the centre. The samples were carefully polished to eliminate vertical scratches or machine marks, and any scratches on the surface were longitudinal, in accordance with ASTM recommendations.[7]

All the rotating-beam fatigue data recorded in this investigation were obtained by rotating the samples under stress on a Moore-type reversed pure-bending fatigue machine. Since the bearing housings were too heavy to permit use of the machine for testing plastics, counterbalances were employed to nullify any stress effects occasioned by these housings.

As in the Prot method, samples must be alternately stressed at various linear rates of increase of stress, this was accomplished, in the case of tests on polymethyl methacrylate, by adding lead shot to a container on the loading yoke. In the work on polystyrene, progressive loading was carried out automatically, using a spring scale loaded by a screw device driven by variable-speed gears. The problem of axial progressive loading was much more difficult, but was solved by means of a specially modified Sonntag fatigue machine, in which the oscillator for progressive loading utilizes the centrifugal force of three unbalanced masses to generate a sinusoidal alternating force, which is steplessly variable from zero to ± 1000 lb.

Experimental Results

In the tests on polymethyl methacrylate, the usual Wöhler fatigue test was first conducted, and the *S-N* curve plotted. The Prot method was then used, with loading rates of 6, 12, 24, 48, and 96 psi per minute. In these tests, some samples were started with no preload, and others with a 500-psi preload, but all points fell fairly close to the line, as shown in Fig. 1. The curve was drawn through points which are averages of eight values. The 95% confidence limits of these means (indicated by dashes) are also shown. The extrapolation of this straight line indicates good agreement of the Prot endurance limit with the Wöhler endurance limit of 900 psi. It should be noted that, in the Prot method, with rates of loading higher than 48 psi per minute, the plot of stress to failure against the square root of the rate of loading (Fig. 1) did not yield a straight line, the higher rates of loading yielding fatigue breaks at stresses lower than might be expected from extrapolation of the straight line obtained by plotting the breaks at slower rates of loading.

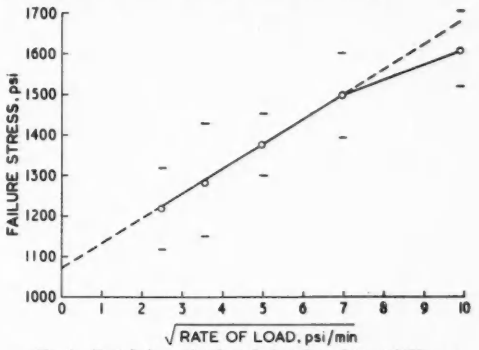


Fig. 1. Prot fatigue of polymethyl methacrylate at 1789 rpm.

In experiments with polystyrene, three different fatigue conditions were observed, i.e., (1) alternating stress at a frequency of 1900 rpm on the as-received material ; (2) alternating stress at 1900 rpm after annealing, to remove all residual stress ; and (3) alternating stress at 360 rpm on the annealed material. In all cases, tests were carried out at 75°F and 50% relative humidity.

As before, the usual Wöhler fatigue tests were conducted, endurance limits being about 460 psi for conditions (1) and (2) above, and 510 psi for condition (3). With the Prot method, the rates of loading found to be most successful were 30, 15, 7·5 and 3·7 psi per minute. When rates of loading higher than 30 psi were used, it was

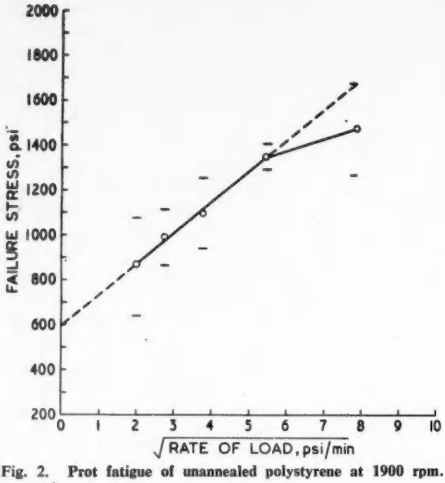


Fig. 2. **Prot fatigue of unannealed polystyrene at 1900 rpm.**

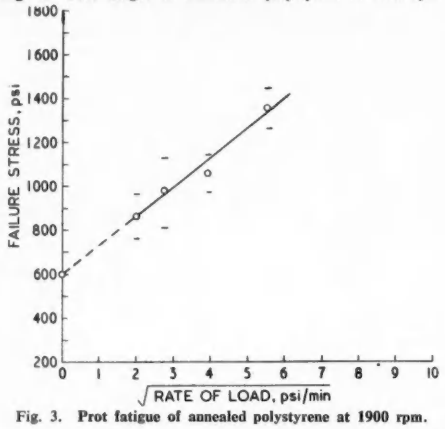


Fig. 3. **Prot fatigue of annealed polystyrene at 1900 rpm.**

found, as in the case of polymethyl methacrylate, that the plot of stress to failure against the square root of loading did not yield a straight line, as indicated in Fig. 2. The Prot curves for all these conditions were drawn as straight lines, by the least-square method, through points which are averages of five values. When these lines were extrapolated to zero rate of increase of load (equal to the endurance limit), a close approximation of the endurance limit, as obtained by the Wöhler method, was obtained. The results of these Prot tests are given in Figs. 2, 3, and 4, in which the 95% confidence limits of the means are also shown. In both the Prot and Wöhler tests, it seems that lowering the frequency raises the endurance limit of polystyrene. Residual stresses present in polystyrene, however, only add to the scatter of the fatigue data. The residual stress work also indicates the excellent reproducibility of the Prot method.

In experiments with nylon, the axial fatigue properties of the material were investigated. The samples were alternately stressed in tension and compression through a mean stress of zero. As before, a Wöhler fatigue study was first conducted, giving an endurance limit of 3300 psi. The Prot experiments were conducted at rates of increase of alternate loading of 15, 7·5, 4·0, and 2·0 lb per min (Fig. 5). It is interesting to note that the Prot extra-

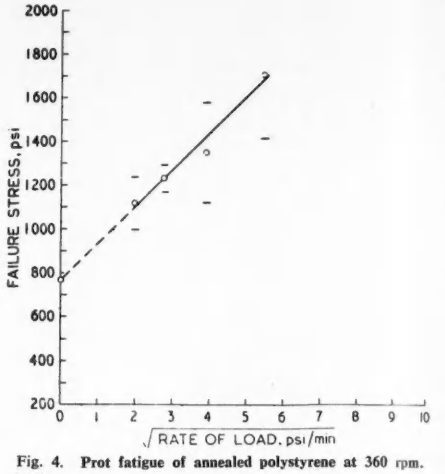


Fig. 4. **Prot fatigue of annealed polystyrene at 360 rpm.**

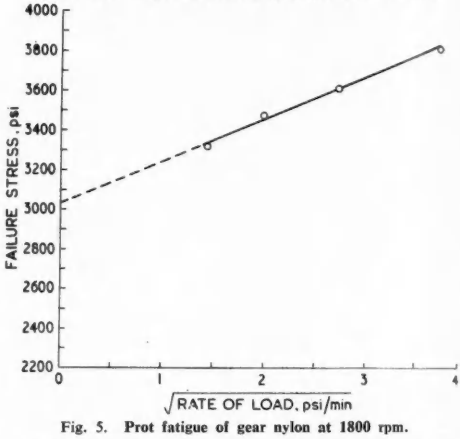


Fig. 5. **Prot fatigue of gear nylon at 1800 rpm.**

polated endurance limit agrees within —7·8% of the Wöhler endurance limit, and that this is the only Prot endurance limit which was lower than a Wöhler endurance limit.

Conclusions

In this preliminary investigation of relatively simple polymer systems under various fatigue conditions, the

References

(1) E. M. Prot : " Fatigue Testing under Progressive Loading ; A New Technique for Testing Materials ". *Revue de Metallurgie*, Vol. 45, No. 12, 1948, p. 481.

(2) F. H. Vitovec and B. J. Lazan : " Review of Previous Work on Short-Time Tests for Predicting Fatigue Properties of Materials ". Wright Air Development Centre Technical Report 53–122, August 1953.

(3) E. M. Prot : " Essais de Fatigue sous Charge Progressive ; Étude de la Dispersion des Résultats ". *Revue Générale de Mecanique*, January 1953.

(4) E. J. Ward and D. C. Schwartz : " Investigation of Prot Accelerated Fatigue Testing ". Wright Air Development Centre Technical Report 52–234, November 1952.

(5) H. T. Corten, T. Dimoff, and T. J. Dular : " An Appraisal of the Prot Method of Fatigue Testing ". *Proc. ASTM*, Vol. 54, 1954, pp. 875–894.

(6) F. H. Vitovec and B. J. Lazan : " Strength Damping and Elasticity of Materials under Increasing Reversed Stress with Reference to Accelerated Fatigue Testing ". Wright Air Development Centre Technical Report 55–225, June 1955.

(7) Fatigue Manual, ASTM. Special Technical Publication No. 91.

Prot method yields a good approximation of the endurance limit as obtained in conventional fatigue testing. The work has shown that, as well as providing a good short-time estimate of the endurance limit under various conditions (a time saving of approximately 90%), the Prot method eliminates the problem of treating data for samples which continue running beyond some arbitrary number of cycles in an ordinary fatigue test. The method also greatly reduces scatter, which becomes large near the endurance limit in a conventional test. Further study of the Prot method of accelerated fatigue testing seems warranted.

U. S. A.

Flame Washing of Steel Castings

By A. F. CHOUINARD. (From *The Welding Journal*, Vol. 36, No. 3, March 1957, pp. 219–224, 9 illustrations.)

THE removal of excess metal, as well as of sand inclusions, sand penetrations, and burned-on core sand, has always been a serious and costly problem. Finishing some castings by conventional methods may bring cleaning costs up to as much as 35% of the total manufacturing costs, about one-third being incurred by chipping and grinding operations. The development a few years ago of flame washing, however, meets the demand for an improved and more economical method of removing excess or defective metal and of bringing castings to a marketable condition without the previous need for chipping and grinding.

Gates, risers, etc. are first removed by an oxyacetylene cutting torch. This can be effected rapidly, but leaves the pad surfaces comparatively rough. As a result, with conventional cleaning methods, some chipping and grinding (by a hand- or swing-grinder) is still required. Flame washing replaces these operations satisfactorily, as shown in Fig. 1, in which the pads on the top and right side of the casting have been flame-washed to provide smooth, even surfaces. The third pad, on the left side, has not yet been flame-washed.

A major advantage of flame washing is the time saved in cleaning the castings. Some foundries have found that, when chill bars and pads are located in positions difficult to grind, or when grinding a surface such as a contour, flame washing can save time. A flame-washing torch is far easier and faster to apply to hard-to-reach spots than even a hand-grinder. If both chipping and grinding are used to clean up a casting, flame washing can cut the cleaning time to from one-quarter to one-third of the original time. Furthermore, capital investment costs are lower for flame-washing equipment than for grinding equipment. To equip a foundry with grinders and a dust exhaust system requires an investment about ten times as great as that for flame-washing equipment. If the latter is installed, only a few hand-grinders are needed, and all swing-grinders and the exhaust system can be eliminated.

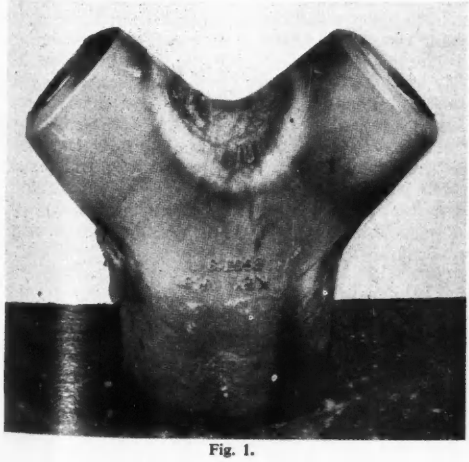


Fig. 1.

As flame washing removes pads and other excess metal on the shake-out floor, castings need not be moved into the cleaning room. Instead, they can go directly for shot-blasting or annealing, if required, and thus skip one handling operation. If production is not too high, one operator can do both cutting and washing by using two separate torches.

An additional advantage is the fact that flame washing does not require nearly as much physical effort as chipping and swing-grinding (which are strenuous jobs, involving a high noise level and vibration fatigue). Moreover, with a 30-in. torch, the operator is not subjected to excessive heat, and training is comparatively easy, about a week being sufficient to convert a good oxyacetylene cutter to a good flame washer, as compared with the three or four weeks necessary to train a chipper or a grinder.

APPLICATIONS OF FLAME WASHING

Riser pads, fins, chill bars, reinforcing nails, and core chaplets make up most of the excess metal which must be removed from steel castings. Riser pads, left from the torch-cutting of gates and risers, can be flame-washed in one or more passes, depending on the width or diameter of pad. A good operator can remove a pad and blend the area in with the casting contour so evenly that it is hard to detect where the pad has been. In this connection, Fig. 2 is a view of a casting, showing at the bottom a gate pad before flame washing and, at the top, the smooth surface left after flame washing a similar pad. An equally smooth result can be obtained with fins at the parting lines. However, at times, so much sand may adhere to the base of a fin that ordinary flame washing may not provide enough heat to melt the sand without gouging the adjacent areas. A special flame-washing torch employing powder injection may then remove the sand and fin more rapidly.

Chill rods and bars, which can be removed by rapping, may be flame-washed, especially if they are located in fairly inaccessible areas. Washing also removes nails and chaplets more rapidly than their shanks can be chipped off.

Particularly difficult to remove are sand inclusions and sand penetrations. Chipping and grinding out inclusions is a slow process, as the sand is below the casting surface. Powder washing removes them quickly, because the powder supplies molten iron oxide, which

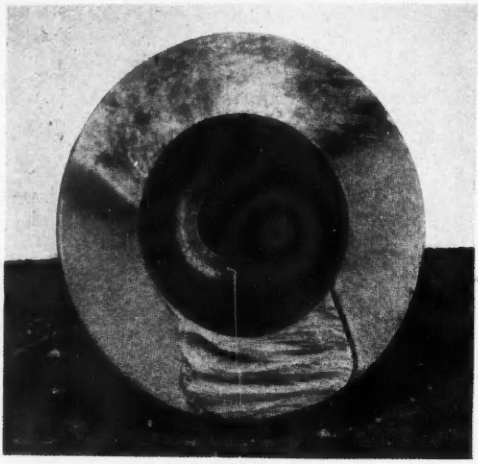


Fig. 2

floats out the sand particles. Powder washing is just as effective for sand penetrations and burned-on core sand. The latter may be especially difficult to remove by chipping, as the hardened, tightly adhering sand may be in recesses almost impossible to reach by chipping hammer.

Flame washing is adaptable to all shapes and sizes of castings. The area that can be flame-washed in one pass is limited by surface heat and may require multiple passes. Steel analysis may restrict its use, because the heat of the process may cause the casting to crack. Trouble may be encountered with castings containing more than 0·30% carbon, although steel with up to 0·50% carbon can be flame-washed without ill effects, if washing is done immediately after shake-out, while the casting is still hot. As a rule, if a casting can be cut with an oxy-acetylene cutting torch, it can be flame-washed. Some irons, stainless steel, and high-alloy steel can be powder-washed.

Flame-Washing Techniques

The equipment needed for flame washing includes, besides the usual oxygen and acetylene cylinders and regulators, only flame-washing torches and tips. Torches are similar to standard oxyacetylene cutting torches, except for length (30 in., compared with the usual 21 in. for cutting torches). They are available with either 75- or 20-deg. heads, the latter being particularly adaptable to the flame washing of interior surfaces.

Recommended gas pressures for flame washing range from 12 to 15 psi for acetylene, and from 65 to 95 psi for oxygen, depending on pad size and casting-section thickness. A higher gas pressure removes large pads more rapidly, but it is necessary to use lower pressures for thin-walled castings. The velocity of the washing oxygen must be high enough to carry away the molten metal without gouging below the contour of the casting and also to keep the tip cool.

Torches should be operated at the full volume of preheat gases to obtain the same advantage of high-velocity gas as a coolant and thus keep tips cooler. At low gas velocity, tips overheat and, as a result, do not last nearly as long as tips operated at full preheat volume. Furthermore, low gas velocity may cause backfires.

Manipulation of the torch, extremely important in flame washing, may be carried out in either of two patterns, i.e., (1) an oscillation with a forward motion or (2) a counterclockwise elliptical motion combined with a forward motion. Oscillation removes metal more rapidly, as more heat is reflected away with the elliptical motion. The more common of the two patterns, used for straight washing of pads and more or less flat areas, is oscillation of the washing tip. If a pad is not larger than 3 or 4 in. in diameter, it is washed in one pass.

The torch is oscillated, with preheat flame only, over a small area (1½ in. wide), to start a puddle and to bring the metal to kindling temperature. The tip is held at about a 30-deg. angle to the surface and pointed in the direction of wash. When the puddle reaches kindling temperature, the washing oxygen is turned on and the forward oscillation motion continued across the pad. The operator must judge the speed of torch movement from the condition of the surface. A fast motion produces a smoother finished surface, with less danger of gouging, and gives better control of the washing action. No attempt should be made to wash any surface which is either too high or too thick. Usually, any pad surface over ½ in. in height is too high to remove by a flame-washing torch. Pads larger than 3 or 4 in. in diameter require more than one pass. For a pad of 8 to 12 in. in diameter, three or four parallel passes should be made. Overlapping of passes produces a uniform surface.

For single- or multiple-pass work, the casting should be positioned so that the wash angle is slightly downwards, permitting the slag to run ahead of the wash and to preheat the area to be cleaned. Flame washing should not be effected in a vertical position, as the slag runs off too quickly to provide any preheating effect.

The elliptical pattern is preferred for washing contour surfaces. It gives a flame concentration and action which quickly feathers the surface metal out into a smooth surface. As in washing by oscillation of the tip, an area is preheated to a puddle and kindling temperature, before the washing oxygen is turned on. While some operators may turn the oxygen on only during the retractory cycle of the elliptical motion, it is more common practice to keep it on continuously, once the proper temperature has been reached. Manipulation of the torch is simpler with a continuous oxygen application, and washing action is faster.

With either oscillation or elliptical motion, the operator should watch a small area ahead of the preheat flame and also the area directly beneath the end of the tip, so as to enable him to feather excess metal down and to blend it evenly into finished dimensions and contours.

Naturally, as an operator becomes experienced, he may vary the techniques here recommended. In flame washing, as in welding, " feel " may mean the difference between a passable job and a very good one. For example, he may change torch position from the recommended 30 deg. to the work surface to as low as 5 deg. to obtain a more positive forward washing action; similarly, he may vary gas pressures to suit working conditions and to produce the best surface quality with minimum washing times.

Powder Washing

Stainless steels and other high-alloy steels (with more than 5% of chromium, nickel, molybdenum, etc.) are virtually impossible to wash with the conventional flame-washing torch. As soon as the flame strikes the metal, refractory oxides of the alloying materials form on the surface and prevent further oxidation. With cast iron also, similar refractories stop the washing action.

Consequently, a special washing torch is used; this adds a highly refined ferrous powder to the washing-oxygen stream of the torch. The powder fluxes and removes the refractory oxides, making it possible and easy to flame-wash the metal surface. The intense heat generated by the reaction between the powder and oxygen melts the oxides as quickly as they form, and the molten iron oxide from the reaction fluxes and dilutes the refractory oxides to form a fluid slag.

The washing action of the powder torch is not true oxidation, as in the flame washing of mild steel with the conventional washing torch. Instead, the intense heat of the powder-oxygen reaction actually melts the material. A similar action—melting of the sand particles—permits a continuous washing action and makes the powder torch more efficient and faster than the conventional torch in washing off sand inclusions, sand penetrations, and burned-on core sand.

The ferrous powder is fed to the torch from a powder dispenser consisting of a hopper, ejector, and a cylinder of carrier gas such as nitrogen or compressed air. The carrier gas, passing through the ejector, entrains, or picks up, the powder and carries it to the tip of the washing torch. A valve automatically controls powder flow.

The washing technique with a powder torch is practically the same as that with a conventional washing torch, except that no preheating time is necessary. The burning powder gives an immediate and continuous kindling temperature, so that washing can begin at once. As in conventional flame washing, the torch is manipulated with either the oscillating or elliptical motion, depending on the work contour.

RUSSIA

Investigations of Sliding Contacts used in Electrical Measuring Circuits

By G. P. ZEDGINIDZE. (From *Elektrichestvo*, No. 1, January 1957, pp. 71–76, 9 illustrations.)

In electrical systems intended for the measurement of strains or temperatures in rotating objects, the sliding contacts used are the critical elements in the measuring circuits. Nevertheless, despite the extensive literature devoted to sliding contacts in electrical machinery, the problems of sliding contacts in measuring circuits have not received sufficient attention and require a fresh experimental approach in each installation.

Silver slip-rings, used in conjunction with silver-graphite brushes, have been extensively used and have given satisfaction at sliding velocities on the slip-rings up to about 3 m/sec. However, sliding velocities between 3 and 20 m/sec necessitate the use of more complicated circuits and pick-up designs, while brush pressures rise to 8 kg/cm². At velocities higher than 20 m/sec, the difficulties become so great that the use of contacts is often avoided, and complex schemes of inductive coupling or various indirect and imperfect methods of measurement are introduced.

Modern engineering requirements include electrical measurements in rotating objects at high sliding velocities of up to 40 m/sec and even higher. Such measurements should preferably be carried out with simple apparatus and without recourse to costly materials such as silver and platinum. The study reported in this article, in which experiments were conducted with slip-rings made of copper, bronze, brass, cast iron, and other metals, and with a variety of brushes, appears to point the way to meeting these requirements.

Normally, a measuring circuit remains open most of the time, and conducts very small currents (between 1 μA and 10 mA) only during actual measuring periods. Hence, it would appear that the contact surfaces (without current) approach the conditions of dry friction of metals associated with characteristic unstable phenomena. It will be shown later that these phenomena can be explained in part by concepts well known in the theory of sliding contacts as applied to electrical machinery, in which the fundamental electro-physical processes are caused by the presence of a current. Such phenomena include the formation of a so-called polish, the sparking accompanied by a "lubricating" action of the current, the generation of additional heat, and the variation of contact resistance with the current passing through the contact.

Examination of the natural brush temperature t_b and the slip-ring temperature t_s, which are functions of the sliding velocity v and the specific pressure N_0 per unit of brush area, show that, when the pressure N_0 reaches 1·5 to

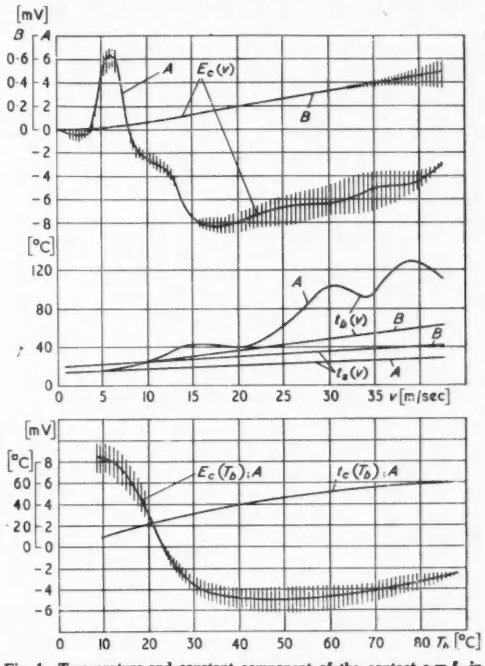


Fig. 1. Temperature and constant component of the contact e.m.f. in a single sliding contact.

(*A*) Cast-iron slip-ring with copper brush (N_0 = 1·5 kg/cm²).
(*B*) Copper slip-ring with copper-graphite brush (N_0 = 2·2 kg/cm²).
The scatter region of the measured results is shown hatched.

2·5 kg/cm², temperatures t_b and t_s are moderate (Fig. 1). In these tests, artificial heating of the brushes was carried out to two different temperatures t_b, and brush and slip-ring temperatures were measured by thermocouples located 0·15 to 0·20 mm from the contact surfaces.

A contact e.m.f. e_c in the single sliding-contact circuit was observed, even with contact pairs of identical materials, its origin being thermoelectric. Oscillographic records show that this voltage is fluctuating, but contains a constant component E_c, which is a function of v and t_b and which, in some contact pairs, changes its sign (Fig. 1) with increasing velocity v. With artificial heating, the change in the sign of E_c can also be observed at a constant velocity v.

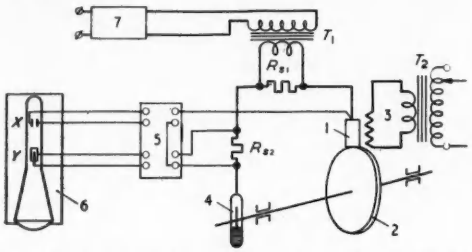


Fig. 2. Diagrammatic layout of the circuit used for oscillographic recording of the voltage-current characteristics of a single sliding contact.

The voltage-current characteristic was examined by means of the circuit shown in Fig. 2, the circuit of the contact under test (brush (1) with slip-ring (2)) being closed via a special mercury switch (4) by low-resistance shunts R_{s1} and R_{s2}. The shunt resistance R_{s1}, fed by an oscillator through a voltage stabilizer (7) and a transformer T_1, serves as the source of e.m.f. for the test circuit. The voltage across the resistance R_{s2}, which is proportional to the current in the circuit and the voltage drop in the contact under test, was picked up through an amplifier (5) and transmitted to the deflecting plates of an oscilloscope (6). Thus, the screen shows directly the voltage-current characteristic required. This characteristic was photographed with the aid of an automatic shutter designed to show one or two oscillations of the 50-cps voltage, thereby ensuring uniform conditions during the process of photographing the entire cycle. Artificial heating of the brushes was effected by an electric heater (3) via a transformer T_2.

These tests have shown that most contact materials exhibit an effect which qualitatively resembles the so-called "cohesion" effect. As long as the voltage drop through the contact pair is small (conditions which exist in measuring circuits), the contact resistance is independent of either voltage or current, but it can be as much as several hundreds of times greater than in the regions where cohesion takes place and where resistance becomes dependent on current (conditions which exist in electrical machines). Cohesion is found only at the beginning of slip-ring motion, but later on it is almost independent of velocity v. With an increase in mean brush temperature T_b, oscillographic records show that the effect vanishes completely, indicating that the nature of the oxide films formed on the contact surfaces is that of a semi-conductor. Where, however, velocity $v = 0$, the film becomes a conductor and, as soon as sliding is initiated, coherence becomes reversible and stable. The explanation of this must lie in the process of continuous renewal caused by the combination of wear and the formation of fresh film material. Small valve effects (2 to 10%) have been observed in all contact pairs. Apart from known causes, such as the semi-conducting properties of films and the contact e.m.f., a Peltier effect may also be present.

The contact resistance r_c was examined with both direct and alternating (15 to 800 cps) currents of very small magnitude, of the order of 10^{-5} to 0·5 A, and was found to fluctuate, its mean value R_c being unstable and sensitive to sliding conditions and to the nature of the materials used. Contact resistance r_c is affected by velocity v only indirectly, through vibrations and frictional heat.

Brush vibrations are excited by machine vibrations and by friction (relaxation oscillations, sticking, and wedging-in of brushes). These vibrations affect the nature of the contact resistance r_c and the contact e.m.f. e_c. They cannot, however, explain the change in sign of R_c and of E_c, nor the effect of mean brush temperature T_b on the fluctuations of r_c and e_c. Tests have established that, after substantial elimination of the causes of brush vibration, by suitable mounting of the brushes, and after eliminating the effect of friction by means of the special device described below, the fluctuations of r_c and e_c did not change qualitatively. This can definitely be ascribed to certain specific film processes.

The coefficient of friction μ and hence the friction force H between the brush and the slip-ring increase with a rise in brush temperature T_b and become stable. However, brush wear G diminishes, as shown in Fig. 3. Similar effects were also observed in a number of investigations into the dry friction of metals, and it is considered that they are associated with structural changes in the oxide films, depending on the temperature of oxide formation.

The results of these tests have made it possible to evolve a number of general concepts regarding processes of film formation on the friction surfaces of sliding contacts in measuring circuits. Thus, semi-conducting oxide films exist on contact surfaces, and these films are subjected to a process of wear and renewal. In the absence of films of water, the contact resistance r_c is basically made up of the resistance r_o of the oxide film and the boundary-layer resistance r_l in layers with a disturbed crystal structure, this resistance being due to the confluence of the current lines in these layers. The remaining factors contributing to r_c are not significant.

In the majority of contact materials, films are removed by a wiping action and not by disintegration. The intensity of wear is proportional to velocity v, and the rate of formation depends on the temperatures t_b and t_c and on the rate of diffusion of oxygen through the film. If the films, e.g., those of aluminium and nickel, are not impermeable to gas, then, after a practically instantaneous formation, they prevent penetration of oxygen, and oxidation occurs only after complete removal of the film, leading to periodic changes in the film thickness δ. If, however, the films are permeable to gas, e.g., those of copper at below 300°C, the penetration of oxygen and the heat from the friction surface are controlled by the thickness of the films themselves, so that, for each value of velocity v, a definite mean film thickness $\Delta(v, t)$ is established on the brushes and slip-rings, and is associated with a condition of equilibrium between the rates of wear and the rates of formation of the film material. However, the thickness Δ cannot be stable, because the slightest external disturbances, such as vibrations, changes in gas pressure underneath the brush, ingress of dirt, etc., change the friction conditions, and thereby alter this sole source of heat generation. This rapidly disturbs equilibrium and

continually causes periodic changes in the mean film thickness δ around the mean thickness Δ. Fluctuations in the thickness of oxide films, and particularly of those on the brushes, explain the fluctuations in the contact resistance r_c and the contact e.m.f. e_c, which persist, even when the brushes are practically vibrationless.

It has already been stated that $r_c = r_o + r_l$, since the total contact resistance r_c is substantially made up of the resistance of the oxide film r_o and the boundary-layer resistance r_l. Now, $r_o = f_1(\delta_o, \rho_o, t_o)$ and $r_l = f_2(\delta_o, \rho_l, t_l, s_0)$, where δ and t are the instantaneous values of the film thickness and temperature respectively, ρ is the specific resistance of the oxide film or of the boundary layer, and s_0 is the ratio of the true area to the nominal contact area. In other words, r_o and r_l are directly associated with the thicknesses δ, as well as with the temperatures.

The layers in the contact area form a thermoelectric circuit consisting of contact materials, each of which is coupled with its own oxide. The periodic shifts in the temperature differences at the dividing surfaces of the various layers are related to the fluctuations in thickness δ and constitute the source of the fluctuating component in the voltage e_c, even in contacts between identical materials. Variations in the mean value of thickness $\Delta(v,t)$ cause the change of sign observed in the constant contact e.m.f. $E_c(v, t)$. The low inversion temperatures of metal oxides also assist the change of sign in E_c.

The film processes discussed above have not been considered in detail, but the following three important practical conclusions can be stated :—

(1) Resistance r_c and e.m.f. e_c are stabilized if the film thickness itself becomes stabilized, in which case it is necessary to ensure at the oxidized surfaces (mainly on the brushes but also within the contact area) heating conditions which are independent of unstable frictional heat. This can be achieved by artificial brush heating.

(2) With an increase in brush temperature T_b, the contact resistance $R_c(v, T_b) \approx R_o + R_l$ will have minima which shift with an increase in the sliding velocity v towards higher brush temperatures, because the oxide-film resistance $R_o(\Delta_o, \rho_o, T_b)$ first drops as a result of the semi-conducting behaviour of the oxide film, and then, when the growth of film thickness Δ_o becomes pronounced, starts to rise.

(3) Taking into account the increase and stabilization of the coefficient of friction μ and hence of the friction force H (Fig. 3, curve H), the brush-heating feature can also be used to eliminate the effect of friction forces on

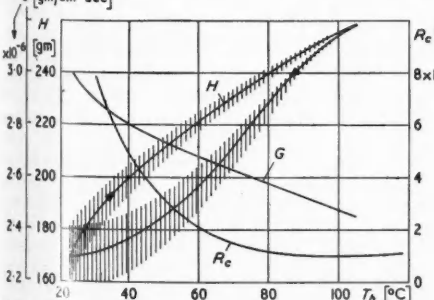


Fig. 3. Friction force H, wear G, and mean contact resistance R_c of a contact pair, comprising a copper-graphite brush and a copper slip-ring, as a function of brush temperature T_b, with $v = 10{\cdot}4$ m/sec and $N_0 = 2{\cdot}2$ kg/cm². The scatter region of the measured results is shown hatched.

brush vibrations. If the brush is set up at a certain angle α against the motion of the slip-ring, as shown in Fig. 4 then the pressure P is resolved into a normal component $N = P\cos\alpha$ and a tangential component $T = P\sin\alpha$, the force T having a direction opposed to that of the friction force $H = \mu N = \mu P\cos\alpha$.

With an increase in μ, which increases with brush temperature T_b, conditions arise in which $\mu = \tan\alpha$, in which case the friction force H becomes equal to the force T and these two forces balance one another. The brush is then under the action of the force N alone. Thus, the problem reduces to the experimental determination of the optimum magnitudes of T_b and α, at which, simultaneously with the stabilization of the film processes, the effect of friction force is also eliminated.

These conclusions have been fully confirmed experimentally and have led to a simple and effective solution of the problem outlined in this paper.

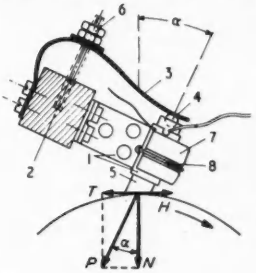


Fig. 4. Method of mounting and heating the brush.
(1) Brush holder. (2) Bridge. (3) Spring. (4) Centering glass ball. (5) Brush. (6) Pressure adjustment. (7) Electric heating element. (8) Mounting for heating element.

Of all the tests carried out, the best results were obtained with a contact pair comprising copper-graphite brushes and copper slip-rings, as shown in Fig. 4. Tests conducted within the limits $v = 0$ to 45 m/sec have established that, with: $\alpha = 18$ to 20 deg. and $N_0 = 1{\cdot}5$ to $2{\cdot}5$ kg/cm², there is an optimum temperature T_b for each value of v. This temperature lies between 65 and 115°C, at which R_c and E_c have minimum values and are stable, and where the fluctuations in r_c and e_c vanish. As an example, Fig. 3 shows a curve of R_c at $v = 10{\cdot}4$ m/sec. It is extremely important that the minima of R_c are not very pronounced, and in practice it appears sufficient to establish a certain mean temperature of 95 $\pm$15°C. It is not necessary to control or to supervise this temperature during operation, owing to its large tolerance, thus simplifying the tests considerably. Contact resistance increases by a factor of no more than 5 to 6, remaining at about 10^{-3} ohm when the velocity v varies between 0 and 45 m/sec, this being achieved with a single brush on each slip-ring and with $N_0 = 2{\cdot}2$ kg/cm². The contact e.m.f. in the circuit does not exceed 25 μV.

Oscillographic records of rapidly varying processes in rotating objects were made by conventional methods of strain-gauge and temperature measurements, observing the most difficult conditions, i.e., (1) each slip-ring was used with only one brush, (2) standard low-resistance (195-ohm) wire strain gauges were employed, the rotating object having only two active strain gauges attached, and (3) a 53-ohm copper resistance thermometer and thermocouples made of standard materials or of copper-constantan were used. The method of current pick-up described does not distort recordings within the range of $v = 0$ to 42 m/sec, and the calibration is unchanged, so that the method can be used with $v = 0$, making it possible to measure very small magnitudes. Similarly, measurement of very large magnitudes is greatly facilitated.

FRANCE

New Torque-Meter with Dynamometer Ring

(From *Mesures et Contrôle Industriel*, Vol. 22, No. 238, March 1957, pp. 255, 257, 259, 4 illustrations.)

THE measurement of transmitted torque is of considerable importance in power plants, industrial drives, and testing machines. Equipment developed for this purpose by the Société d'Application de Dynamométrie Industrielle (S.A.D.), and described in this article, comprises a set of dynamometer rings of different sizes and materials suitable for various ranges of torques and operating speeds.

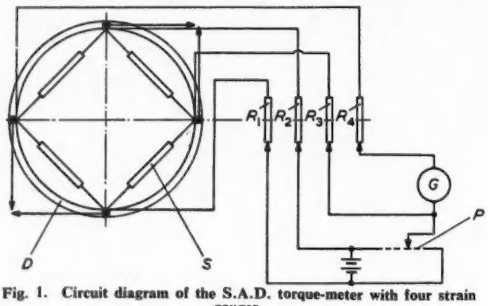
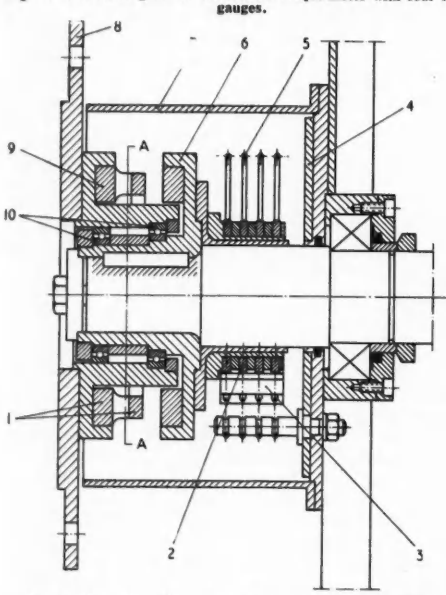


Fig. 1. Circuit diagram of the S.A.D. torque-meter with four strain gauges.



Basically, the dynamometer comprises a hollow, thick-walled cylinder with two long parallel slots or series of slots cut around different portions of its periphery, so that it is, in fact, more like three rings connected together by bridge-pieces. The important feature of this component is that the ring, although subjected to torque, is used to indicate the tensile and compressive strains caused by such torque, enabling it to make use of the modulus of elasticity, instead of the shear or rigidity modulus of the material. For this purpose, the dynamometer ring is provided with either four or eight strain gauges, suitably arranged for measurements of bending strains and forming a bridge, the output of which is proportional to the applied torque.

The bridge is connected by two slip-rings R_1 and R_2 to a battery supplying the necessary d.c. voltage and to a potentiometer P, as shown in the circuit diagram in Fig. 1, which applies to an arrangement with four strain gauges S. The output from two other slip-rings R_3 and R_4 is connected to a mirror galvanometer G or to an amplifier and oscilloscope or pen-recorder, slip-ring R_3 also being connected to the slide of the potentiometer P. The bridge is automatically compensated for thermal and centrifugal effects, and the dynamometer ring D can be operated at high speeds, owing to suitable positioning of the strain gauges S with regard to hoop stresses. The bridge supply voltage is 20 V when the equipment is used with four strain gauges of 600 ohms each, or 9 V with eight gauges of 120 ohms each. The bridge output voltage is of the order of 30 mV for maximum torque.

Two sizes of ring are available, with respective diameters of 120 and 160 mm. Moreover, irrespective of amplifier gain, sensitivity can be varied by using rings made from different materials, so that a wide variety of torque ranges can be catered for, i.e., 0 to 3, 0 to 10, and 0 to 30 mkg for the 120-mm size, and 0 to 100 and 0 to 300 mkg for the 160-mm size. For protection against dirt, etc., the ring is provided with a metal housing.

An example of a complete torque-measuring unit, comprising the dynamometer ring (1), the slip-rings (2), and the associated brushgear (3), enclosed in a housing (7), is shown in Fig. 2. A flange (8), which is bolted directly to an engine flywheel, transmits torque to the dynamometer ring (1) with its strain gauges (11) through an inner casing (9) which is supported by ball bearings (10). At its other end, the dynamometer ring is attached to another casing (6), which is keyed to the shaft. The housing (7) is itself stationary, and the end-cover forming part of this housing carries four terminals (5) for connecting the brushes, three brushes for each slip-ring being provided. The four slip-rings (2) are made of silver, and the brushes of silver-graphite. By means of a rotatable disc (4) on the end-cover, the brushes can be raised clear of the slip-rings when measurements are not being taken, thereby reducing wear to a minimum. A special device is incorporated for cleaning the slip-rings, ensuring that contact is satisfactory and that the ring will have a uniform surface in all tests. Since the limiting factor, insofar as operating speed is concerned, is the peripheral rubbing speed of the brushes, the slip-ring and brushgear arrangement is constructed in two different sizes, permitting maximum speeds of 6000 and 9000 rpm respectively, the corresponding bores of the slip-ring carrier being 28 mm and 50 mm. The two slip-ring carriers are interchangeable, i.e., either can be fitted in the dynamo-

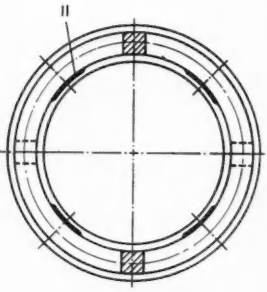


Fig. 2. Section through a complete S.A.D. torque-measuring unit.

(Concluded on page 220)

British Industrial Developments

Mains-Frequency Coreless Induction Melting Furnace

Now in operation at International Combustion Limited, Derby, Britain's first mains-frequency coreless induction melting furnace, a 300-kW, 5-ton capacity unit, has been manufactured and installed by Birlec Limited, of Birmingham. Basically, the principles of this type of furnace are similar to those of conventional high-frequency units, the fundamental difference between the mains-frequency furnace and the high-frequency furnace being that it has now been found practicable in furnaces of capacities larger than 15 cwt to supply the coil with current at normal mains frequency, i.e., 50 cps, instead of at frequencies between 1000 and 10,000 cps, with considerable economy in running cost. The 50-cps current induces a vigorous stirring action in the bath, ensuring that the entire depth of molten metal is at a uniform temperature and of uniform composition.

The coil, of a specially shaped section, is wound from high-conductivity copper and is designed for maximum electrical efficiency, for safety in the event of a metal break-through, and for free passage of the necessary cooling water. The coil is supported and restrained axially by spring-loaded end-rings, and radially by packets of transformer iron, which also constrain the magnetic flux and permit the use of a solidly welded steel outer casing.

The furnace itself imposes virtually no maximum temperature limitation, other than that engendered by the lining material chosen. The first lining of the present furnace is of a high-silica material rammed around a sheet-steel former which is melted out with the first charge, thereby sintering the lining. The life of the lining of furnaces of this type has been found in practice to be satisfactory up to very high temperatures. Thus, when melting iron, the life is normally about 150 heats with a pouring temperature around 1500°C. With steel, the life of one lining may be between 30 and 150 heats, depending on the temperature, type of material used, and the care exercised in carrying out repairs. For light alloys, the life of the lining may be considered indefinite.

The furnace is tilted for pouring by hydraulic rams, one on each side of the body. These are supplied with fluid by a vane-type pump controlled by a valve mounted on the control stand of the furnace platform. The rams are of large diameter, giving mechanical rigidity and low operating pressures, resulting in a very smooth and progressive tilting action.

The present installation runs off a low-tension supply of about 420 V, which is fed to the equipment through a contactor and an isolator. The main on-load contactor is provided with overload protection, backed up by H.R.C. fuses and an off-load isolator. The transformer is provided with adequate tappings to ensure a wide range of power inputs, so that any degree of superheating or melting, up to the maximum, can be achieved. In the same tank as the transformer is a reactor, associated with a static balancer, to give a reasonably balanced three-phase load on the incoming supply mains. In order to present a good power factor to the mains, a bank of 50-cps power-factor correction capacitors is provided, connected in parallel across the coil. Current is brought to the furnace from the busbars by water-cooled flexible cables, while cooling water for the coil is fed via flexible hoses. The illustration shows a slagging view of the furnace, with the control panel in the background.

Heavy-Duty Spiral Electric Planing Machine

Recently completed to the order of William Asquith Ltd., a heavy-duty spiral electric planing machine, capable of machining work 14 ft wide, 10 ft high, and 30 ft long, has been constructed by George Richards & Co. Ltd., of Broadheath, Altrincham, Cheshire. In addition to normal longitudinal planing, the machine (Fig. 1) is arranged to carry out cross-planing, deep cross-planing, and surface grinding (with its own coolant system).

The table has a working surface of 30 ft × 12 ft 3 in., is liberally provided with T-slots for clamping purposes, and has a chip tray at each end. The bed is of heavy box section and is provided with four slideways, each 60 ft in length, the total width of the bed being 11 ft 6 in. Adequate support is therefore given to the table over its whole length and throughout its maximum stroke. The narrow-guide principle is incorporated in the table design, and a special strip affords adjustment for sustained alignment. Lubrication of the four bed slides and the driving worm box in the centre portion of the bed is effected by two motor-driven oil pumps, the supply of oil being obtained from a sump in the bed of the machine. A special feature is that, by means of electrical interlocks, it is impossible to start the main motor of the machine unless the oil pumps are running. Oil sumps are also provided at each end of the machine, to receive surplus oil from the bed slides during the traverse of the table. The machine is driven from the a.c. supply by means of a Metropolitan-Vickers Ward-Leonard set and an 80-hp variable-speed d.c. motor. Cutting and return strokes are controlled by entirely independent rheostats, a range of speeds from 10 to 130 fpm being available in both directions.

Two tool boxes are fitted on the cross-slide and are provided with hand, automatic, and rapid power traverse, both vertically and horizontally ; angular adjustment by

means of a worm and quadrant, is also provided. The heads are quite independent of each other, and the feed mechanism incorporated in the feed boxes gives a fine range of feeds from 1/96 in. to $\frac{1}{4}$ in., and a coarse range from $\frac{1}{32}$ to $\frac{3}{4}$ in. per stroke of the table to the cross-slide boxes horizontally and the side boxes vertically. The feed ranges to the cross-slide boxes vertically are half those provided horizontally. For the return stroke, the tools are lifted by means of solenoids which operate at the end of the cutting stroke and remain energized until the tools are ready to begin cutting again. In the event of the table stop-button being pressed during the return stroke, the solenoids remain energized, thereby preventing damage to the tool or workpiece. Each head is controlled by its own switch on the cubicle and the lifting arrangements are therefore quite independent of each other. Side tool boxes are fitted to each upright, and automatic feed and rapid power traverse are provided in the vertical direction, hand adjustment being provided in the horizontal direction. Here again, tool lifting is accomplished by means of solenoids. Feed and rapid power traverse motions are interlocked, to prevent damage by simultaneous engagement.

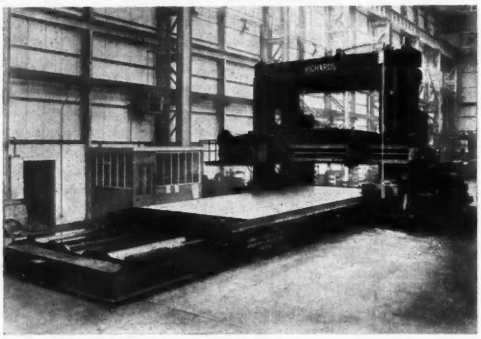


Fig. 1.

The counterbalanced cross-slide is unusually deep on the main slide, with increased depth where the cross-slide fits the uprights, eliminating deflection and counteracting the torsional stresses set up by heavy-duty cutting. Locking of the cross-slide on the uprights is accomplished by means of two $\frac{3}{4}$-hp motors, which, through suitable gearing, operate clamp plates bearing on the inner square lock of the upright, one at the top and the other at the bottom of the cross-slide. These motors are also interlocked with the main motor, to prevent the table being put into operation while the cross-slide is unlocked. Raising and lowering of the cross-slide is actuated by the same 9-hp motor which provides power for the feed and rapid power traverse motions. This motor is also interlocked with the cross-slide clamping motor, to prevent the elevating mechanism being put into motion whilst the slide is locked. Limit switches are provided at the top position of the cross-slide to obviate damage from over-run, and similar provisions are made from the bottom limit of the side tool boxes and to prevent collision of the cross-slide and side tool boxes. Machine movements are controlled from a twelve-point counterbalanced pendent-type push-button station.

The machine is provided with a detachable cross-planing head having a stroke of 12 ft 9 in. from the inside face of the left-hand upright. Hand adjustment vertically and horizontally is also provided. The normal left-hand planing head is mounted on a long saddle which carries the cross-planing unit, and for driving this attachment a special driving box is fitted to the left-hand end of the cross-slide, via a 15-hp motor mounted on the back of the cross-slide. Motion to the head is obtained through a screw running the length of the cross-slide and engaging nuts on the saddle. The length of stroke is controlled by

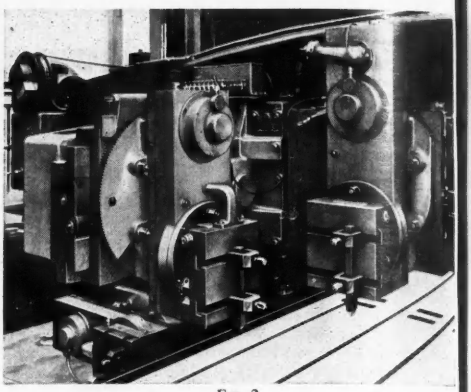


Fig. 2.

a large dial carrying adjustable dogs engaging with a reversing switch, and a safety switch is provided to prevent accidental over-run. A change-over switch controls either longitudinal or cross-planing, as desired, and acts as an interlock between the longitudinal and cross-planing motions. For longitudinal planing, the direction of the main motor and the operation of the feed motor are controlled by the table reversing switch operated by adjustable dogs on the table. For cross-planing, the direction of the head and the operation of the feed motor are controlled by the reversing switch operated by adjustable dogs on the dial at the left-hand end of the cross-slide. The feeds to the cross-planing head are provided by the feed box used for longitudinal planing, the feeds for both motions being the same and indicated on the dial provided on the feed box. Motion to the cross-planing feed driving shaft is provided by the down-feed shaft in the cross-slide. Selector gears are provided for either cross or vertical feed to the cross-planing head. Electrical interlocks are incorporated to prevent conflicting motions operating at the same time and, as in the case of the normal heads, tool lifting for the cross-planing head is solenoid-operated. The cross-planing attachment in its normal position is shown in Fig. 2.

As previously mentioned, the cross-slide is counterbalanced. This is the first time that this feature has been incorporated in a Richards planing machine and is primarily designed to steady the cross-slide as it commences the deep cross-planing operation. Balancing also materially assists in the elevating of the cross-slide. The necessary interlocks are actuated during deep cross-planing—the main motor to the table and the rapid power traverse to the heads both being rendered inoperative. For deep cross-planing, the tool slide on the cross-planing attachment is swivelled 90 deg. from the vertical position.

A "Snow" grinding head, with a 20-in. diameter grinding wheel, is interchangeable with the right-hand planing head and is accommodated by removing the normal planing head and attaching to the saddle by means of an adaptor plate.

Thin-Walled Plain Bearings for Heavy Engineering Applications

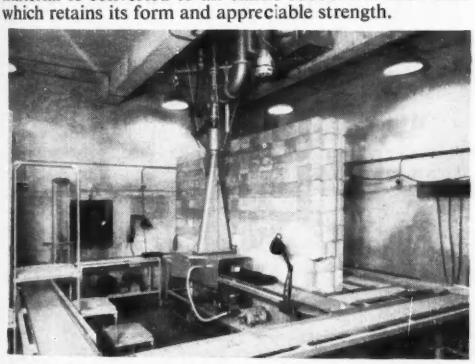
Suitable for marine, locomotive, and stationary diesels, and for gearboxes, turbines, and other types of heavy machinery, a new range of standard thin-walled plain bearings, in sizes up to 12 in. bore, has been introduced by The Glacier Metal Company Limited, of Alperton, Middlesex. The new bearings are made in two standard wall thicknesses, i.e., 0·142 in. for the 6 to $8\frac{3}{4}$ in. bearings, and 0·172 in. for the 9 to 12 in. bearings. Individual bearings are available in widths up to $6\frac{3}{4}$ in., but wider bearings can be provided by using two stan-

dard bearings side by side, with a gap between them forming an oil groove, in accordance with a patented arrangement.

These bearings are made to close wall-thickness tolerances, and are manufactured from strip material by a continuous process, which lends itself to close control and consistent metallurgical quality. Other advantages of these thin-walled bearings include the fact that they can be replaced without special plant or unskilled labour, that spares are light in weight and save storage space, and that their use in thick-walled shells frequently gives designers the option of increasing shaft sizes to carry greater loads without increasing the overall size of the assembly (or, in the case of big-ends, reducing the weight of the connecting-rod assembly). Another advantage is that they are supplied prefinished, i.e., to a wall-thickness accuracy which enables them to be fitted without machining or scraping, thereby greatly reducing fitting and assembly time. Furthermore, their accurate bore size and contour result in a better load distribution than that normally obtained in practice with hand-scraped bearings.

High-Energy Radiation Research on Dielectric Materials

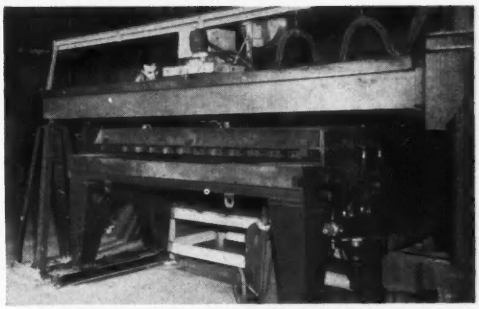
Among other research projects in progress at the Hinxton Hall Research Laboratories of Tube Investments Limited, is an investigation into the effects of high-energy radiation on dielectric materials suitable for use in cables and wiring. Of these materials, polythene is of particular interest, because of its superior electrical, physical, and processing properties, and it is one of the aims of the present investigation to supplement existing knowledge of the effects of irradiation on these properties with a wider investigation into the fundamental changes which are induced. Thus, for instance, it is known that exposure of polythene to high-energy radiation considerably improves its high-temperature properties. Unlike conventional polythene, which melts at 115°C, the irradiated material is converted to an elastic rubber-like substance which retains its form and appreciable strength.



For the purpose of these investigations, a new laboratory has recently been constructed by the Tube Investments Group, the focal point of the building being a large two-storey chamber which houses a 2-MV Van de Graaff particle accelerator. A conveyor-belt system passes the materials through the electron beam produced at a regulated speed. The operation is remote-controlled from an external panel, and the inside of the chamber can be viewed through a thick observation window comprising 41 panels of glass which also protect the operator from any stray radiation. The whole installation is enclosed in a concrete shell, 3 ft in thickness, equipped with a 2-ton lead door. The illustration shows part of the irradiation chamber, in which can be seen the lower half of the accelerator and the triangularly shaped electron-beam scanner. The observation window is in the background.

Sheet-Welding Machine

Stated to be the first machine to have been designed and constructed to accommodate thin-gauge mild-steel sheets for lap welds, as well as butt welds, a new sheet-welding machine has been supplied by Courtbourn Positioners Limited, of Bedford, to F. J. Ballard & Co. Ltd., of Tipton, Staffs., thus making possible the redesign of their industrial ovens to suit an all-fabricated construction. Thicknesses from 20 s.w.g. to $\frac{1}{8}$ in. for lap welds and to $\frac{1}{4}$ in. for butt welds, with widths up to 9 ft, can be handled by this equipment.

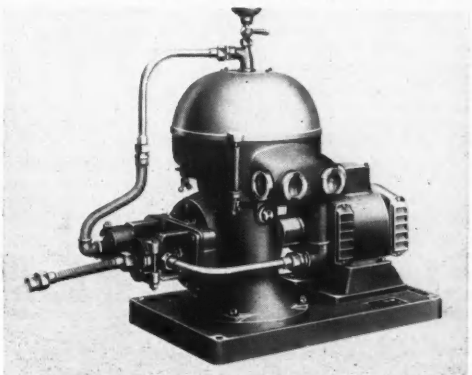


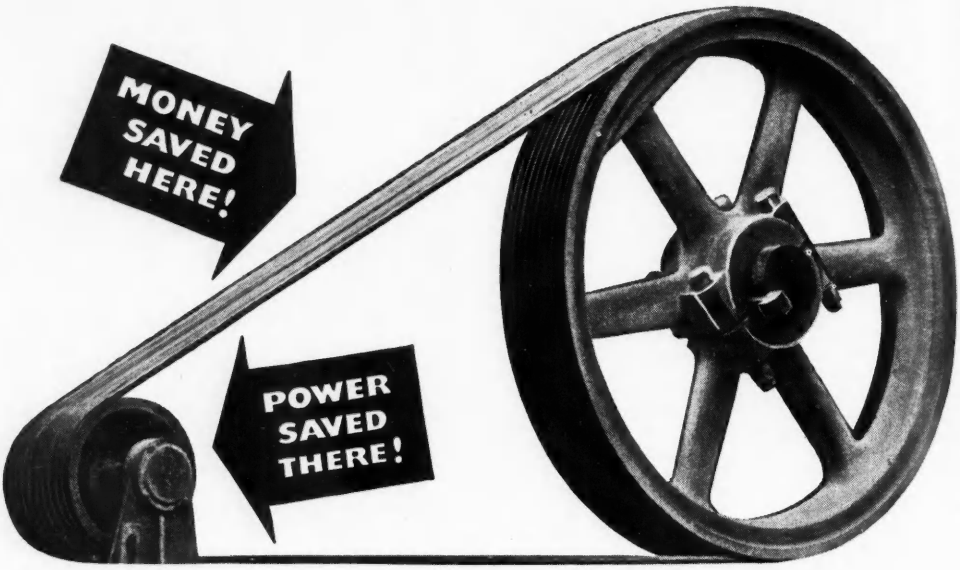
One sheet of the material to be welded is fed in under the clamping beam on one side of the machine up to stops in the form of hinged locating arms which are dropped down onto the weld path. The sheet is then clamped by operating a single air valve controlling a bank of 14 clamps, after which the locating bars are swung back out of the way, and a second sheet is fed in from the other side of the machine, positioned in correct relation to the first sheet, and itself clamped by a second bank of 14 clamps. A Lincoln submerged-arc automatic head is then set in operation, rapidly traversing the full length of the welding path, and providing a smooth, even weld which requires no fettling.

High-Capacity Centrifugal Separator

A new centrifugal separator has recently been added to their standard range by the Centrifuge Department of Hopkinsons Limited, of Huddersfield, with the object of providing a high-capacity unit within reasonably small dimensions. In this connection, the new machine, designed "2X", is capable of handling 275 gallons per hour of various fuel oils and lubricating oils, yet stands only 33 in. high on a base of 29 × 18 in.

The separator is operated by a $1\frac{1}{4}$-hp motor, mounted on a combined bed-plate and drip tray, with a flexible



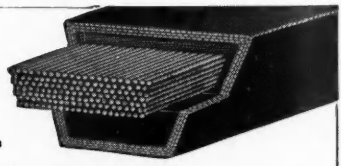


...When Goodyear V-Belts are on the job!

You get longer belt life, more efficient transmission with Goodyear V-Belts. There's a wide range of these ' job-designed ' belts to suit every kind of drive — from huge multi-V installations to small F.H.P. applications. The Goodyear Service will help you select the right V-Belt for the job and advise on optimum working conditions. In this way, you can be sure of the greatest economy and the elimination of costly shutdowns.

Consult your Goodyear Industrial Rubber Distributor or write to:

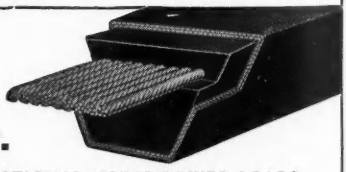
The Goodyear Tyre & Rubber Co. (G.B.) Ltd., Industrial Rubber Products Dept., Wolverhampton.



E.C.V.

FOR MULTI-V INSTALLATIONS

Withstand high starting torques, sudden shocks and pulsating loads. Minimum stretch and creep. Tough, rubber-impregnated fabric preserves the belt section, resists side-wear and gives positive grip.



F.H.P.

FOR FRACTIONAL HORSE POWER LOADS

Will absorb the shocks and strains of frequent starting and stopping. Also designed to withstand the high rate of flexing arising from the compactness of short centre, high speed, small pulley drives.

GOODYEAR INDUSTRIAL RUBBER PRODUCTS

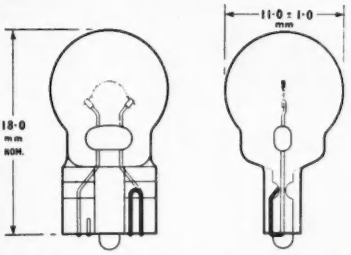
V-BELTS · TRANSMISSION BELTING · CONVEYOR BELTING · INDUSTRIAL HOSE

coupling between the motor and worm-wheel shaft and incorporating a centrifugal clutch lubricated by oil mist. The motor is of the enclosed, ventilated, drip-proof type, with specially impregnated windings for operation in tropical climates. In the main drive, the phosphor-bronze worm-wheel and steel worm are enclosed in an oil bath, the pump drive being via spur gears, also lubricated by oil mist.

Different designs of centrifuge bowl are available, to suit varying types of duties. The body, top cover, and locking ring of the bowl are constructed of heat-treated, nickel-chrome steel, machined all over, with a protective coating of nickel, the centre-tube and sealing cone being made of phosphor-bronze. All parts of the bowl are protected against corrosion. Portable-type machines are also available, if required.

Capless Electric Lamps

A new development in miniature lamps, the capless lamp, is announced by the A.E.I. Lamp and Lighting Co. Ltd., of London, W.C.2. The new lamp, which should prove of great value in electronic equipment, control panels, and domestic appliances, has a number of inherent advantages, including compact design, resistance to humidity and vibration, and operation at high temperatures (up to 600°F).

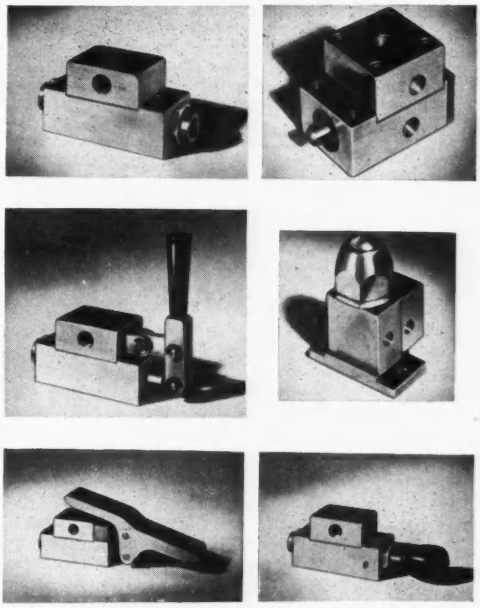


The lamp has no metal cap, no cement, and no soldered connections, but uses an accurately moulded glass base with formed lead-wire contacts symmetrically disposed on opposing faces about a centrally moulded tubular section, as shown in the accompanying illustration of a 12-V, 2·2-W type. Lead-wire contacts are formed closely to the glass faces and are terminated at the end remote from the seal outlet by a groove moulded across each face of the glass base. This moulding provides registration for both light centre length and axial alignment and offers great scope for simplified socket design without sacrificing reliability of performance.

Pneumatic Control Valves

An improved version of the slide valve, as used to control compressed air and low-pressure hydraulics, forms the basic unit of a comprehensive range of control valves manufactured by Midland Pneumatic Ltd., of New Cross, Wolverhampton. Based on the linear slide-valve principle, and combining extreme simplicity, few working parts, and limited valve movement, the valve consists of a body housing a simple balanced piston which traverses the valve slide across a lapped ported face. The piston is fitted with low-friction seals in a plain bore of honed finish. When arranged for reversal by means of a pilot air signal, the valves incorporate synthetic-rubber buffer rings, absorbing the inertia of the moving piston and providing a shockless reversal. All working parts are constructed of entirely non-corrodible materials of copper alloy or stainless steel, but, if required they can be specially produced from ferrous materials.

These valves, which are totally enclosed, rugged, and dependable, can be used under exacting conditions, while an ample reserve of operating power, coupled with low friction losses, ensures immediate response to signal



pressure. In addition, their limited movement reduces operator fatigue, particularly with foot-operated valves. The basic unit is arranged for 4-way control, of either positive, self-reversing, or self-centering action, the latter being available with ports either blanked or open to exhaust in the neutral position. These four different types can be supplied in all cases for hand, foot, pad, mechanical, automatic, or semi-automatic control, or in combinations of these various styles. A selection of types and control arrangements is illustrated. At the moment, valve sizes of $\frac{1}{4}$ and $\frac{3}{8}$ in. B.S.P. are available, but larger sizes will be added later to the range. In addition, a pilot solenoid, for attachment to the basic unit, is in the development stage.

Cutting Tools with Throw-away Tips

Eliminating the need for tool reservicing, a new range of cutting tools, embodying the expendable-tip technique, is announced by the Wimet Division of Wickman Limited, of Coventry. Designed on the principle of clamped-tip tools, these new "Econotip" tools consist of a shank or holder to which a carbide tip and a separate chip-curler are fixed in a prepared location. As each cutting edge becomes work-dulled, the tip is released and turned round or over to present a new sharp cutting edge, until the eight edges on the square tip or the six edges on the triangular tip have been used, after which the old tip is merely discarded and a new one inserted.

The elimination of the regrinding or lapping process also secures substantial savings in the cost of diamond wheels, normally a very desirable but necessarily expensive requirement of conventional carbide tools. It also removes the risk of tool failure and shortened life due to incorrect grinding. Moreover, because it is unnecessary to remove the tool to renew the cutting edge, tool settings remain undisturbed, and unproductive time taken up in resetting tools is greatly reduced. The system also ensures that the carbide tip is completely free from brazing stresses, and is thus capable of longer and more profitable service than that sometimes obtained from brazed tools.

Extensive tests have shown that the life of an Econotip holder is infinite, though, to allow for the unavoidable

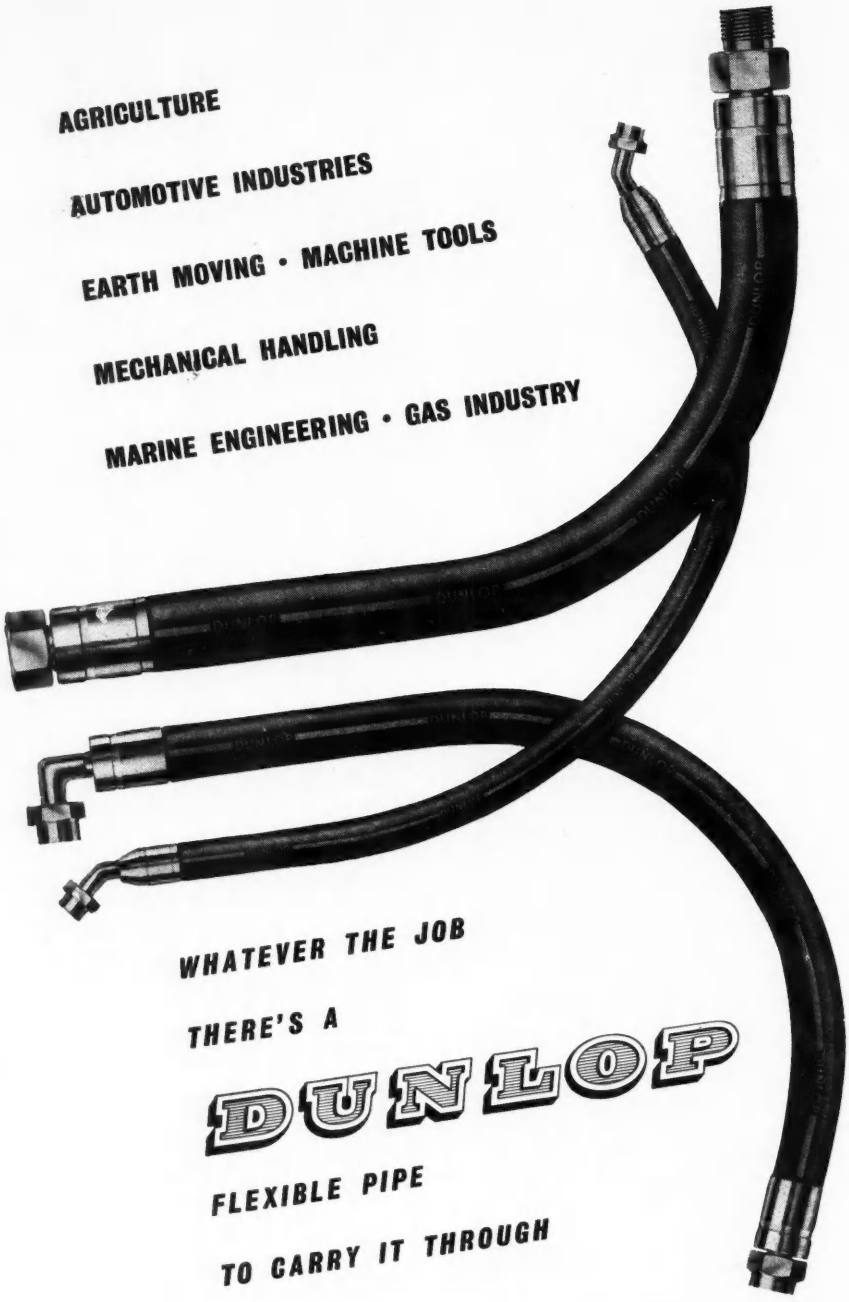
AGRICULTURE

AUTOMOTIVE INDUSTRIES

EARTH MOVING • MACHINE TOOLS

MECHANICAL HANDLING

MARINE ENGINEERING • GAS INDUSTRY



WHATEVER THE JOB

THERE'S A

DUNLOP

FLEXIBLE PIPE

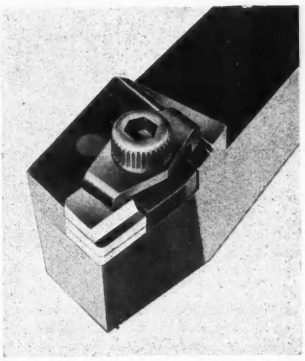
TO CARRY IT THROUGH

Dunlop Technicians will always advise on any problems concerning installation of Flexible Pipes. Write please to ;—

DUNLOP RUBBER COMPANY LIMITED • ST. GEORGE'S ROAD • COVENTRY • TELEPHONE: COVENTRY 64171

6H/90

hazards of the machine-shop, a conservative estimate of a life of 288 production runs (i.e., periods between relocations of the tip) has been taken as one of the bases of a series of calculations which show conclusively that the use of Econotip tools represents a saving of about 35%, compared with the use of conventional brazed-tip tools.



The design of the Econotip holder has been carefully studied to give great rigidity and extremely long life. The holder itself is made from toughened high-carbon steel, with a seating for the carbide tip and the chip-curler. The seating for the tip and chip-curler is designed to accommodate two tips, the lower tip acting as an anvil for the cutting tip and as a wear-resistant face immediately below the tip, to prevent chips of swarf abrading the shank itself. When a chip-curler is not required, the tips can be secured by reversing the clamp. The tip seating is arranged to give a 5-deg. negative cutting rake and the normal 5-deg. front-to-back angle.

Four styles of tip are available, giving approach angles of 15, 30, or 45 deg. with a square tip, and 0 deg. with the triangular tip. Two grades of carbide are available at present, i.e., Wimet grade " N " for machining cast iron, non-ferrous, and general-purpose cutting, and Wimet grade " XL2 " for cutting steel at high speeds. Depths of cut up to ¼ in. with fine feeds can safely be taken with these tools, subject to the usual conditions governing the use of carbide tools.

Aerosol-Packed Protective Coating for Metal Components

Suitable for the protection of machine-tool parts, spares, gauges, stores, and all other metallic parts exposed to corrosion, a new hardened-resin type of lacquer, designated " Ruby ", is announced by Amber Oils Ltd., of London, W.1.

When sprayed onto metal surfaces, " Ruby " forms a hard corrosion-inhibiting coating which is strongly resistant to scuffing and abrasion and will not crack under conditions of heat and moisture. Once applied, it will remain intact for a considerable time, but it can, when required, be removed by readily available solvents, such as paraffin or white spirit. The coating has a red colour, facilitating examination and providing economy of application.

Plastic Plumbago Refractories

Basically comprising plumbago/silicon carbide plastic refractories, requiring only the addition of water to be ready for use, a new range of refractory products, designated " Black Sal ", is announced by The Morgan Crucible Company Limited, of London, S.W.11.

Of these, Black Sal No. 900 is a cement with a plumbago/silicon carbide base, primarily intended for jointing plumbago ware, though it can also be used as a refractory wash-coat. Black Sal No. 2000 is a high-quality plumbago stopper plugging compound, which is very resistant to erosion, thereby making it ideally suitable for this purpose; furthermore, it acts as a safeguard against the loss of the stopper plug in bottom-pour ladles.

Black Sal No. 1000 is a super-quality plumbago/silicon carbide plastic ramming material for use in foundries. It has excellent resistance to thermal shock, and is resistant to corrosive action from molten metals, slags, and most fluxes, while its self-glazing properties restrict oxidation when heated to a temperature between 1400 and 1500°C in an oxidizing atmosphere. In addition, it can be used as a damp dust for ramming behind formers, as a soft damp dust for hand-hammering without formers or for moulding shaped parts, and as a soft plastic for hand-daubing and repairing cracks.

Surface Contacts with High Loading Pressures in Corrosive Atmospheres

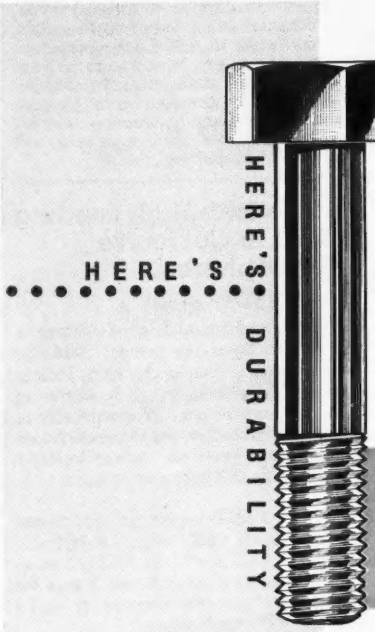
(*Concluded from page 190*)

given loading. Finally, the conduction of current is taken over by the foreign layer, the contact resistance becoming current-dependent. Frequently, then, voltage drop remains approximately constant with increasing current, whereas it decreases roughly proportionally to current when the latter is reduced, owing to partial fusion or " fritting ". In any case, however, voltage losses in the foreign layer are so high that the contact is not technically suitable.

Tests in Rooms 2 and 3 were carried out with copper blades plated with thin, fairly thick, and thick layers of silver, the blades being stored for 35 or 97 days, as in previous tests. The results obtained in Room 2 were the same as in Room 1, the voltage drop being lower with a thin layer than with a thick layer of silver.

With increased intensity of corrosive attack through the thin silver layer, the base copper was finally affected in the tests carried out in Room 3. In this case, it was found that fairly thick coatings gave a lower voltage drop than thin and thick coatings. In addition, measurements were made on all the types of coating previously mentioned. After 97 days storage in Room 2 the foreign layer was so considerable that current conduction took place mainly within the foreign layer itself. Only the dip-tinned surface still had a surface deformation capacity which was so considerable that current conduction remained metallic, with contact resistance practically independent of current intensity.

To complete the tests described above, a number of components of low-tension high-power fuse-gear was suspended in Room 2, with and without their fuses inserted. The jaws of the bottom portions and the blade ends of the low-tension high-amperage fuses were silver-coated to a thickness of 12 microns, the contact force being approximately 35 kg. Owing to the splayed design of the contact blades used, the load-carrying contact surface was comparatively small, and contact pressure was correspondingly high, so that the deformation of the foreign layer was even greater than in the surface contacts described above, despite the lower contact pressure. In this series of tests, half of the contacts were ungreased, and the other half covered with vaseline. Before the exposure test, the voltage drop was measured as approximately 0·7 mV at 350 A ; after 97 days storage in Room 2, the values measured at 350 A were 32 mV open contact, ungreased, without fuse inserted, and 0·8 mV, with fuse inserted ; and 5 mV open contact, greased, without fuse inserted, and 0·75 mV, with fuse inserted. These figures clearly show the protection afforded by grease in this very corrosive atmosphere. On their external surfaces, these components suffered considerable attack, their colour being dark-blue and black, both on ungreased and greased components.



HERE'S ACCURACY

STAINLESS STEEL
BOLTS · NUTS · STUDS
ACID AND HEAT-RESISTING

We are specialists in the manufacture of Bolts, Nuts, Studs and Machined Parts in all classes of Heat-Resisting and Stainless Steels.

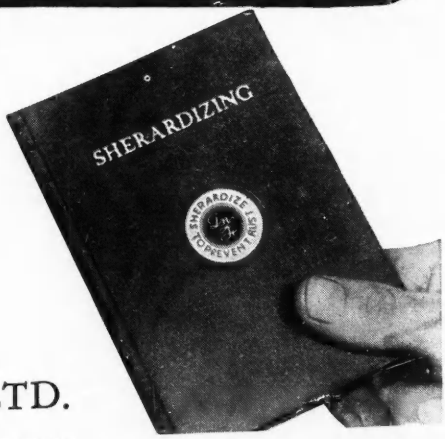
THE SANDIACRE SCREW Co LTD
SANDIACRE • NEAR NOTTINGHAM
PHONE · SANDIACRE 2065/6 • GRAMS · SCREWS, SANDIACRE

All products are machined from bar materials.

YOURS *for the Asking*

LEARN HOW TO:—
SPECIFY,
TEST,
USE,

SHERARDIZING



ZINC ALLOY
RUST-PROOFING CO. LTD.

SHAKESPEARE STREET, WOLVERHAMPTON

TELEPHONE: WOLVERHAMPTON 20647/8/9

ALSO AT LONDON & ROCHDALE

ADDITIONAL ABSTRACTS

Numerous important abstracts which, for lack of space, cannot be published in our main editorial columns are regularly included in condensed form in this section. Subscribers may obtain photostat copies of all original articles at cost.

Boundary-Layer Measurements at Supersonic-Nozzle Throats.

By M. SIBULKIN. (From *Journal of the Aeronautical Sciences, U.S.A.*, Vol. 24, No. 4, April 1957, pp. 249–252, 264, 8 illustrations.)

THE use of the momentum-integral-equation method of calculating the boundary-layer thickness corrections for wind-tunnel nozzle contours is widely known and has been partially confirmed by experiment. More recently, the boundary-layer integral equations have been used to calculate the heat transfer to wind-tunnel and rocket-nozzle walls. In these cases, the region of greatest interest is the nozzle throat, since the heat-transfer rates are greatest there. An intermediate step in calculating local heat-transfer rates is the determination of the local boundary-layer momentum thickness. Consequently, measurements were made at several supersonic-nozzle throats to study the boundary layers there and to test the values of predicted throat momentum thickness.

As described in this paper, wall-static-pressure measurements and boundary-layer pitot-pressure surveys were made near the throat of a flexible-wall supersonic-wind-tunnel nozzle at three settings, with throat radii of curvature from 33 to 59 in. It was found that the longitudinal static-pressure gradient at the nozzle throat calculated from one-dimensional flow theory agreed with the measured wall-static-pressure gradient. The boundary-layer velocity profiles at the nozzle throat are presented and discussed. The boundary layers were turbulent and 0·046 to 0·107 in. thick. It was found that the boundary-layer momentum thickness at the nozzle throat calculated, using the momentum integral equation and several approximations, agrees with the values determined from the measured boundary-layer profiles. Finally, it was noted that, in spite of the different static-pressure gradients, the boundary-layer velocity profiles for the different nozzle settings are similar, and it is shown analytically that this similarity is to be expected.

Pressure-Induced Diffusion and Deformation during Precipitation Processes.

By M. HILLERT. (From *Jernkontorets Annaler, Sweden*, Vol. 141, No. 2, 1957, pp. 67–89, 2 illustrations.)

MOST processes in physical metallurgy are treated as if they took place under uniform temperature and pressure. Metals are good thermal conductors, and the assumption of uniform temperature is therefore justified in most cases. Often, the assumption of uniform pressure, on the other hand, does not seem justified, in view of the high mechanical strength of solid metals. In the present paper it is shown how pressure differences are originated during solid-state precipitation processes, and the effect of such differences on the course of the process is examined in some detail. Only binary systems are considered, in order to simplify the treatment as much as possible.

As a result of the investigations discussed in this paper, it is suggested that the diffusion flow of a component in non-isobaric systems is proportional to the activity gradient. An expression for the pressure dependence of activity is derived, and the difference in volume between a precipitate and the transformed part of the matrix is calculated. It is concluded that the precipitate is growing under a hydrostatic pressure, if this difference is positive. In addition, formulae are derived for the volume supplied by mechanical deformation due to such a pressure and for the deformation energy. Three different assumptions regarding the mechanical behaviour of the matrix are used, i.e., the elastic, the ideally plastic, and a creep model. The hydrostatic pressure and the growth rate of a spherical precipitate are calculated. The usual kinetic law, dr^2/dt = constant, is found for the elastic and the ideally plastic models, when the interfacial energy is negligible. For the creep model it is found that there are shifts in rate-controlling mechanism at certain particle sizes, and at the same time a shift in kinetic law. When the rate-controlling mechanism is diffusion, the kinetic law is dr^2/dt = constant, and when the control is shifted to a creep mechanism, the law is changed to $d \log_e r/dt$ = constant. The creep model is applied to the growth rate of graphite in steel, and the effect of the alloying elements Mo and Cr is calculated. Comparison with experiments shows good agreement.

It is suggested that diffusion of carbon is the rate-controlling process for the growth of graphite in cast iron when the graphite particles are large. At a smaller particle size, the necessary deformation of the austenite by creep plays some role.

Compressible Gas Flow in Commercial Pipes.

By B. MILLS and B. N. COLE. (From an advance copy of a paper submitted to *The Institution of Mechanical Engineers, London*, May 1957, 18 pages, 16 illustrations.)

THE literature of incompressible steady flow through circular pipes is by now very extensive, and is reasonably complete for the purposes of most engineering applications. Very little attention, however, seems to have been given to the correlation between what may be called the hydrodynamic surface roughness and actual direct measurements of surface roughness. Outstanding among the earlier experimental inquiries into the case of compressible gas flow through round pipes was that due to Keenan and Neumann in 1946 ; the conclusion reached, for subsonic adiabatic flow in hydraulically smooth pipes, was that frictional losses were independent of Mach number, and depended only upon Reynolds number in a manner identical with that for incompressible flow. So far as the present authors are aware, however, no enquiry has yet been made into the compressible-flow characteristics of commercial grades of piping in which surface-roughness effects may be considerable. This omission has meant in many cases that the pipework of a compressed air installation has received only a fraction of the true design consideration devoted to the compressor plant itself, despite the fact that the pipework may frequently have represented the major capital outlay.

With these observations in mind, the following main purposes were undertaken : (a) To discover how far the findings of Keenan and Neumann might be extended into the range of appreciable wall roughness as exhibited by commercial grades of pipe ; (b) to correlate the results of compressible flow tests on such grades of pipe with existing information on incompressible flow and with direct measurements of surface roughness ; and (c) to revise the theory of steady, compressible flow in a manner suitable for speedy use in design calculations. The investigation has been restricted mainly to adiabatic and subsonic flow.

From the results of the investigation described in this paper, the following conclusions are drawn :—

(1) For the compressible, subsonic flow of a gas in a pipeline of commercial degree of roughness, the value of Darcy's friction factor f depends on Reynolds number

Do you know the name for Plastics Mouldings?

Family men, enlisting the aid of their offspring, will probably be rewarded with ADDLIRGE or even DIDLARGE. Astute Buyers will, however, know that the name synonymous with Plastics is ALDRIDGE!

ALDRIDGE is a comparatively new name in the moulded plastics field. It is a vigorous Company enjoying the benefits of the most modern factory and plant, and administered and staffed by men whose knowledge and experience of plastics mouldings extends back to the beginning of the Industry itself. ALDRIDGE make all types of thermo-setting and thermo-plastic mouldings for the leading names in many Industries . . . . . ALDRIDGE is ready to serve YOU!

ALDRIDGE for PLASTICS mouldings

ALDRIDGE PLASTICS LTD.

An A.E.I. Company

REDHOUSE INDUSTRIAL ESTATE, ALDRIDGE, STAFFS.
TELEPHONE: ALDRIDGE 52031 (4 LINES)

A.I.D. APPROVED. CONTRACTORS TO H.M. GOVERNMENT DEPARTMENTS

L.G.B.

exactly as for incompressible flow, and is independent of Mach number.

(2) If a pipeline is made up from sections of greatly varying roughness, while the order of assembly of the sections will have no effect upon the overall pressure loss, the pipeline as a whole may be expected to show an apparent decrease in effective mean roughness (as interpreted in the light of the Colebrook-White equation) as Reynolds number increases.

(3) Using such facilities as those proposed in this investigation, calculations of compressible, adiabatic flow may be performed rapidly and with good accuracy in cases where macroscopic roughness variation is small. Under specific conditions, a given pipe will possess definite maxima for both fluid-carrying capacity and power-transmission capacity, each of which may be assessed quickly by methods provided.

(4) In cases where a substantial departure from the adiabatic condition must be faced, a correction, based on an assumed linear variation of stagnation temperature along the pipe, may, in the circumstances, prove to be the most manageable.

(5) Adequate correlation exists between the roughness ratio k/d, as used in the Colebrook-White equation and a similar ratio to be evaluated by the centre-line-average method from records of direct surface measurement. In assessing the latter ratio, as many traces as possible should be used, in order to allow for macroscopic variations of roughness. The authors suggest that a C.L.A. integrating surface meter, giving a direct reading of the C.L.A. index, could save much time in making such an assessment, as planimeter work would thereby be eliminated.

Diesel-Engine Lubricants and Oil Alkalinity.
By A. Dyson, L. J. Richards, and K. R. Williams. (From a paper presented at a meeting of *The Institution of Mechanical Engineers, London*, May 17, 1957, 16 pages, 15 illustrations.)

The main functions of heavy-duty lubricating-oil additives are to control engine fouling, bearing corrosion, and wear of liners and piston rings. Alkalinity is desirable for the control of wear and is one of the major requirements for the avoidance of piston fouling, when conventional organo-metallic additives are used. In a well-balanced oil, sufficient dispersive power and oxidation stability may be incorporated to ensure adequate piston cleanliness and freedom from bearing corrosion, provided that the alkalinity level is satisfactory.

As pointed out in this paper, the alkalinity level falls during service and, for satisfactory performance with certain types of additive in common use, must be kept above a minimum value. For these additives equations are given which enable the variation of the alkalinity level with time in given circumstances to be predicted approximately. The most satisfactory arrangement is to use an oil containing sufficient alkalinity, so that the concentration never falls below the critical value. The oil-change period is then determined by other considerations, e.g., contamination with abrasives. If an oil of lower alkalinity-concentration is used, then the equations developed permit an approximate estimate of the oil-change period, determined solely from the aspect of additive effectiveness. The application of these results to engines with separate cylinder lubrication is discussed. Thus, oils and, where appropriate, oil-change periods may be selected on a rational basis instead of by trial and error.

It is considered definitely possible to relate additive depletion to various engine-design and engine-operating factors and thereby ensure satisfactory results with additive-type lubricants. Furthermore, it is shown that, when heavy-duty oils are used over extended periods, the deterioration in engine condition is not necessarily a gradual process permitting considerable latitude in oil-drain practice, but may be a relatively rapid one which can lead to catastrophic results in severely rated engines. The proper selection of oils and oil-change periods is therefore very important.

The initial rate of neutralization depends on the fuel-sulphur throughout but, after the engine has been running for some time, alkalinity concentration depends strongly on oil-consumption rate. Two-stroke engines and four-stroke engines with prechambers give higher neutralization rates than four-stroke direct-injection engines. Thus, the neutralization rate tends to increase with increasing combustion-chamber swirl. The results are only approximate, but have already proved successful in predicting engine-oil requirements. It is interesting to note that the oil-change periods calculated from the above considerations have nearly always been in line with the recommendations of engine manufacturers. However, such recommendations are of necessity general in nature, and the methods described in this paper make it possible to take into account the particular circumstances of a given engine, thereby permitting the most economic application of the lubricating oil. Further evidence is being accumulated continuously, and it is hoped that predictions may eventually be made with greater accuracy ; for this purpose, however, it may well be necessary to take into account detailed factors in engine design to an extent not possible at the present moment.

Finally, it is suggested that the differences of rates of depletion with different types of combustion system merit further examination and consideration by engine designers.

Brittle-Fracture Propagation in Wide Steel Plates.
By W. J. Hall, R. J. Mosborg, and V. J. McDonald. (From *The Welding Journal, U.S.A.*, Vol. 36, No. 1, January 1957, pp. 1s–8s, 13 illustrations.)

It is well known that steel may fracture in a brittle manner under certain conditions, but, in many applications, the probability of brittle fracture may be minimized by giving proper attention to such variables as type of material, geometry, temperature, and stress level. Also, in selected applications, it is now possible effectively to use crack arresters, which may retard or stop the propagation of a brittle fracture. However, a clear understanding of the brittle-fracture mechanism is still unavailable and needed for the eventual development of satisfactory design procedures.

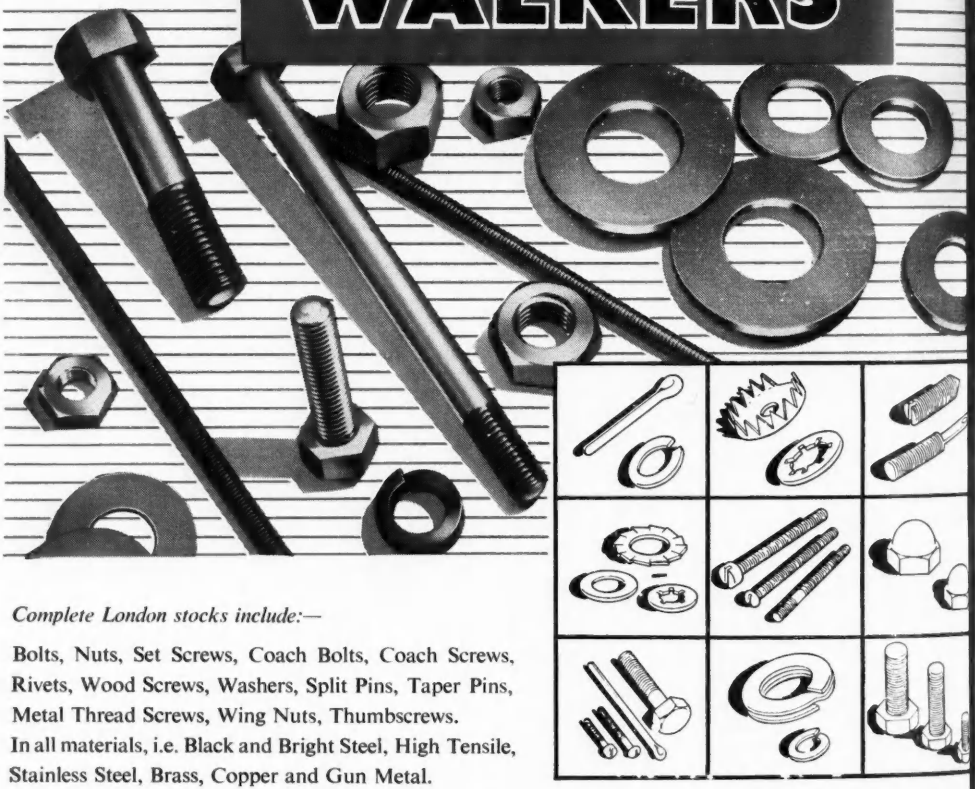
The object of the investigation described in this paper is to study the propagation of brittle fractures in wide steel plates. Initiation, propagation, and occasionally arrest may be considered as three interrelated stages of the brittle-fracture process. Although the interrelationship prohibits a completely independent study of any one stage, the large-scale specimen helps to separate the various stages to some degree. In this study, the method of initiation may not be too important, if the starting technique can be shown to have little effect on the plate behaviour during fracture propagation.

The first major problem of this programme was to decide what should be measured and in what manner it might be accomplished. After a thorough study of the problem, it was decided that crack speed and strain distribution in the plate should be investigated initially. Little of the brittle-fracture work reported previously has included high-speed measurements during propagation. Thus far in the programme, tests have been made on two sizes of specimens and most of these specimens have been instrumented to measure strain response and crack speed.

Fracture initiation studies and instrumentation are described primarily for the benefit of other investigators. Striking tests, made on several specimens which did not fracture, indicate that small strain changes were produced by the notch-wedge-impact method of fracture initiation. A typical test record from plates, 2 and 6 ft in width, is presented to illustrate the type of data obtained from these tests. General observations relating to strain response, crack speed, and fracture appearance are presented.

You won't often see a *PACK* OF WOLVES, or a *PRIDE* OF LIONS, or a *SKULK* OF FOXES but you'll always find a FLOCK OF FASTENINGS

at **WALKERS**



Complete London stocks include:—

Bolts, Nuts, Set Screws, Coach Bolts, Coach Screws, Rivets, Wood Screws, Washers, Split Pins, Taper Pins, Metal Thread Screws, Wing Nuts, Thumbscrews.
In all materials, i.e. Black and Bright Steel, High Tensile, Stainless Steel, Brass, Copper and Gun Metal.

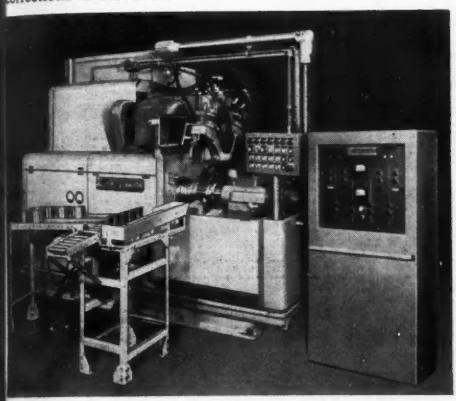
If any of your requirements are in the nature of NON STANDARD or SPECIAL ITEMS to your own particular details contact us if you require assistance, our wide knowledge and experience as SPECIALISTS is at your service.

M. W. WALKER & STAFF LTD
ENGINEERS' MERCHANTS
IBEX HOUSE, MINORIES, LONDON, E.C.3
'Phone: ROYal 8191 (10 lines) 'Grams: Makerlaw, Fen, London
MIDDLE EAST BRANCH—BAHRAIN, PERSIAN GULF

New Materials, Processes, and Equipment

AUTOMATIC LATHE WITH FEED-BACK CONTROL

Featuring automatic handling, chip disposal, gauging, sorting of workpieces, and tool adjustment, the operation of the new "self-resetting" automatic lathe developed by the Jones & Lamson Machine Company, of Springfield, Vermont, closely approaches that of a continuous process control, anticipating the possibility of the process exceeding permissible limits by instituting corrections in advance.



Workpieces are handled by automatic transfer arms and are turned by a flat carbide disc-type cutting tool mounted on the carriage. Chamfering tools are mounted on the back-arm. The turning tool is automatically adjusted in two ways, i.e., it can be moved in and out through a total range of 0·0020 in. radially in steps of 0·0002 in., or it can be rotated in 100 steps, so as to use the entire periphery of the cutting edge. Sorting of workpieces is accomplished by trapping the finished piece at a roll-over station on the delivery conveyor and depositing it into the appropriate station, according to whether it is satisfactory, oversize, or undersize. Gauging is effected by means of a proximity gauge mounted on the back-arm of the lathe, while the piece, is still rotating.

ELECTRONIC COLOUR-PRINTING CAMERA

A new electronic device intended to simplify considerably colour-printing processes is announced by Hadley Telephone and Sound Systems Ltd., of Smethwick, Birmingham. Designated the H.P.K. Autoscan, the new apparatus may be considered as a reproduction camera with an electronically controlled light output for scanning coloured copy and for producing colour- and tone-corrected separation negatives.

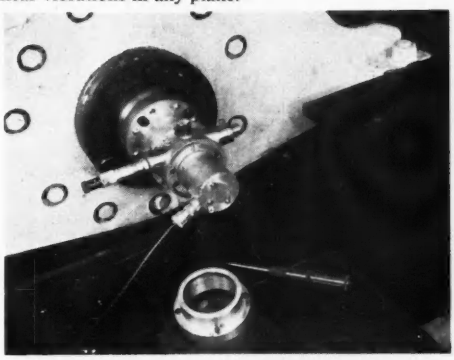
It should be understood that the Autoscan is not a conventional electronic scanner of the type already well known in process engraving, in which a printing block is produced by means of a stylus cutting into plastic or metal. On the contrary, it is a direct contribution to the problem of producing colour-corrected negatives which do not need excessive retouching, such negatives being produced in the Autoscan by a special system of colour and density control. A great advantage is that no attempt is made to record unsuitable densities and then to correct electronically; instead, a highly sensitive beam scans the coloured original, and the impulses are recorded directly on a photographic plate.

The equipment can be used for reflection copies, such as oil paintings, water-colours and combination drawings, and for colour-reproduction prints of all kinds. The maximum size of copy is 24 × 24 in., with a maximum negative size of 20 × 16 in. Enlargements up to 1½ diameters, and reductions down to one-third can be made. No special darkroom is needed, and the apparatus is suitable for any normal reproduction colour process.

TORSIONAL VIBRATION PICK-UP

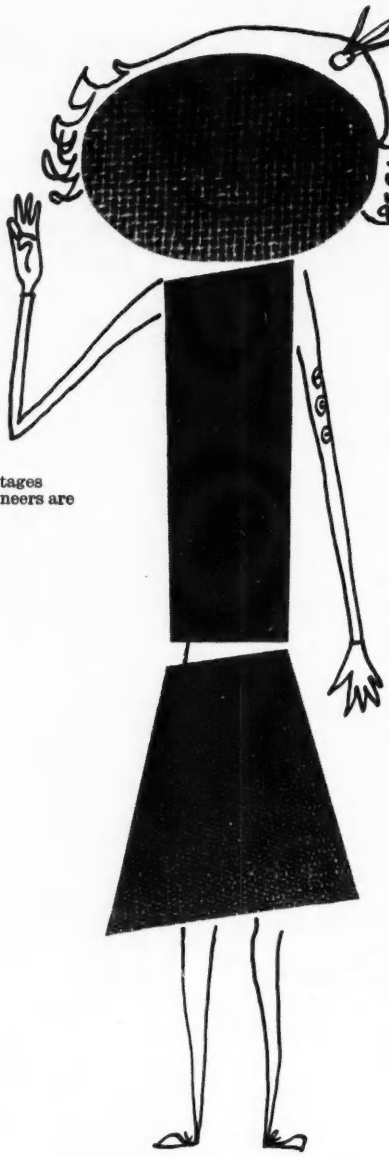
Designed to measure the amplitude of torsional oscillation or cyclic variation at the free end of a shaft, the new model G218 torsional vibration pick-up, announced by Southern Instruments Oscillograph Division, of Camberley, Surrey, is particularly applicable to internal combustion engine crankshafts and camshafts, gearing systems, machine-tool drives, and all types of shafting.

In this instrument, which was shown at the recent Physical Society Exhibition, a powerful permanent magnet forms the seismic inertia, which is mounted in precision bearings inside a casing attached to the fixing flange of the pick-up. A copper cylinder, surrounded by a steel shell, encloses the magnet, and the magnetic forces between these members and the magnet itself provide the elastic coupling and the damping necessary. When the pick-up is fixed to a shaft which is rotating non-uniformly or oscillating, the seismic inertia tends to rotate at uniform velocity or to remain stationary. The angular movement between the inertia and the casing is detected by a probe moving into an inductor fixed to the case of the unit. This inductor is connected to the inner coil of a concentric pair forming the coupling unit. The outer coil, wired to the output connector, is mounted on bearing and is thus free to remain stationary when the rest of the unit is rotating. The sensing element is designed for use with a special FM amplifier system. In this case, the output of the FM pre-amplifier is directly proportional to amplitude of oscillation and may thus be applied to an oscillograph, analyser, or voltmeter, to enable accurate measurements to be made throughout the frequency range, without the need for integrating stages or calibration curves. The pick-up is practically insensitive to linear vibrations in any plane.



The pick-up may be calibrated by detaching part of the cover and fitting the calibrating jig provided. A micrometer on the jig enables the inertia to be displaced through small angles relative to the casing. The pick-up and its associated amplifier and recording equipment can then be accurately statically calibrated throughout, immediately prior to or following a test, with the pick-up in its operating position.

Guides are made of Ferobestos



A glance at these unique advantages shows why more and more engineers are specifying Ferobestos.

great physical strength
high strength to weight ratio
high temperature resistance
low moisture absorption
good chemical resistance
high wear resistance
good electrical resistance
high dimensional stability
low coefficient of friction

The versatility of Ferobestos, an asbestos-reinforced plastic material, opens up an extremely wide range of engineering applications. As well as guides these include:—

Bushes
Coupling Discs
Bearings
Gears & Rollers
Piston Rings
Wearing Slippers
Mounting Pads
Compressor Blades
Thrust Washers

Ferobestos is available in a number of special grades including silicone impregnated for greater heat resistance and graphite impregnated for more efficient lubrication.

Ferobestos can be supplied from stock in sheets, rods, and tubes. Special mouldings, where quantity justifies the cost, can be made to order. Write for fully detailed and illustrated leaflets.

J.W. ROBERTS LTD

FEROBESTOS DEPARTMENT

Chorley New Road, Lostock, BOLTON. Tel: Horwich 840 · *Branch Sales Offices: LONDON, GLASGOW, BIRMINGHAM, LEEDS*

A Member of the Turner & Newall Organisation

SMALL VACUUM FORMING MACHINE FOR PLASTICS

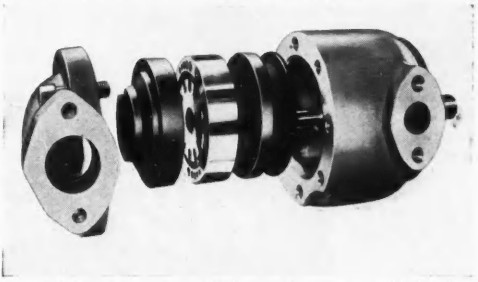
Primarily designed for prototype and short-run production, a new small vacuum forming machine for plastics, developed by M. L. Shelley & Partners Ltd., of London, S.W.5, is of neat and simple design and occupies relatively little floor space. Mounted on the base is a ½-hp electric motor, driving a vacuum pump which exhausts the pedestal column forming the vacuum reservoir. At the top of the column is the working surface, on which is mounted the mould box, with a mould area of 12 × 12 in. A 1250-W electric heater is supported by a threaded tube and is adjustable for height. The clamping frame is adjustable and is locked by a toggle clamp, thus permitting different heights of mould box to be used.

In operation, a sheet of plastic is laid on top of the mould box and is clamped by the frame to form an air seal. The heater is then brought over the sheet and, after a predetermined period, the box is exhausted, drawing the sheet into or over a mould. The heater is then swung clear, the clamp released, and the sheet removed and trimmed.

BALANCED-VANE HYDRAULIC PUMPS

A new series of balanced-vane hydraulic pumps for continuous service at 2000 psi and supplying rated deliveries of up to 100 U.S. gpm at speeds up to 1800 rpm is announced by the Denison Engineering Division, American Brake Shoe Company. Known as the "T" series, these pumps, which feature an exclusive hydraulically balanced vane, are available with either clockwise or counterclockwise shaft rotation, the direction of rotation being easily changed by indexing a cam-ring to a dowel-pin hole, with an arrow indicating the desired rotation.

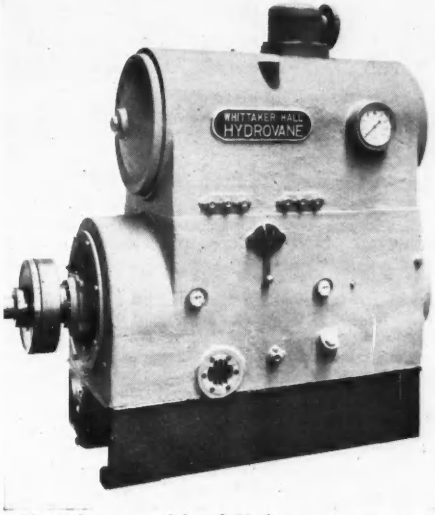
The pump, an exploded view of which is illustrated, consists of a housing which provides an outlet connection, a bore for supporting the shaft bearing and shaft assembly, and a larger bore which contains a floating pumping cartridge, comprising a front-port plate, vane, rotor, and cam-ring assembly, and a rear-port plate with a shaft-end support bearing. By providing maximum shaft support, the bearings permit the pump to be used in applications with higher shaft side-loading. As the port plates are not a part of the pump housing, the inlet-port plate and the pressure-discharge port plate are constructed of a material specially selected to give maximum resistance to wear. However, should it be necessary to replace these plates, this can be effected easily by removing the end cap and sliding out the cartridge. To provide the requisite clamping force on the pumping cartridge, the pressure-loaded port plate is designed in such a way that the clamping force is always slightly greater than the deflecting or spreading force.



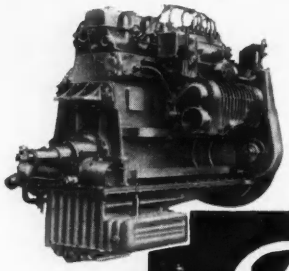
Additional gains in efficiencies have been obtained as a result of the fully balanced design, not only of the rotor, but of the vanes themselves. The balanced vane is achieved by a construction which permits the vane to be open at both ends to pressure on the pressure stroke, and to suction on the suction stroke. Other advantages of these pumps include trouble-free starting under any weather conditions and ease of mounting. In this connection, the pump may be face-, foot-, or flange-mounted in any of four positions on its mounting bracket, while the suction inlet port can be assembled in numerous selected positions relative to the pressure delivery port.

AIR-COOLED ROTARY COMPRESSORS

Completing the range of smaller machines made by Alfred Bullows & Sons, Whittaker, Hall & Co. Ltd., of Radcliffe, Manchester, announce a range of larger sizes of oil-vane or "Hydrovane" compressors, with capacities up to 600 cfm. These compressors are completely air-cooled and self-contained and, being flange-connected to motors, do not require any further alignment after mounting on simple foundations.



These larger models of Hydrovane compressor (a 600-cfm model is illustrated) comprise two stages of compression, each with its own pressure-lubrication and cooling system acting also as the sealing medium. No circulating pumps or valves are required and, as they are



Here's the RELIABILITY industry demands

Industry has been looking for just such an engine as this—an engine that takes up very little space and uses fuel sparingly, yet gives power in plenty for the job on hand and keeps going year after year with the minimum of maintenance. A dependable, versatile, hard working, economical engine.

GENERAL SPECIFICATION

No of cylinders, 6; Total cu. capacity, 4090 c.c. (250 cu.in.); Maximum b.h.p. at 1800 r.p.m., 105; Compression Ratio, 14-1 approximate; Firing order, 1, 5, 3, 4, 2, 6; Fuel consumption, under ·40 lb. b.h.p. hr.; Oil consumption less than 1% fuel oil.

Foden FD

4, 6 & 12 CYLINDER
2 STROKE OIL ENGINES
50/240 B.H.P.

COMPRESSORS *The power developed so economically by the Foden FD 6 makes it an ideal power unit for the compressor.*

ROAD ROLLERS *The ever reliable Foden 2 stroke oil engine is first choice for the modern type of road roller.*

RAIL SHUNTERS *The Foden is being used more and more in rail shunters where its flexibility and low fuel consumption are greatly appreciated.*

STATIONARY ENGINES *give better, longer service, take less space and cost less to run with the dependable Foden 2 stroke oil engine.*

BY APPOINTMENT
MOTOR TRACTOR MANUFACTURERS
TO THE LATE KING GEORGE VI

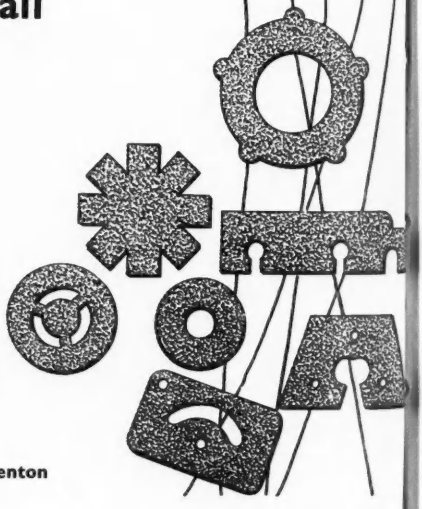
CHAMPIONS OF THEIR WEIGHT AND CLASS

Send for details to—
ENGINE DIVISION
FODENS LIMITED
SANDBACH · CHESHIRE

LANCASHIRE

FELT

for Gaskets, Washers and all Fabricated Parts



Research and modern practice has established FELT as the ideal medium in its own particular field. Its many uses are wide in both the Electrical and Mechanical Industries. We have been Manufacturers of FELT for over a century and can supply everything you need from the smallest WASHER to the largest FABRICATED component.

Send us your patterns, stating quantities required for keenest quotations.

Approved for AID, ARB, and IFV inspection

THE LANCASHIRE FELT CO LTD

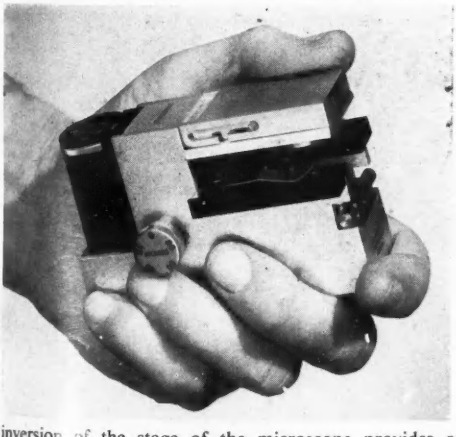
Denton, Manchester Tel: Denton 2613-4-5 Cables: Lancfelt, Denton

designed as a complete unit, they are free from any external pipe-work or accessories. Oil separation is in three stages, with full-flow filtering, the discharged air being virtually oil-free at temperatures which are lower than those previously obtained with any other type of compressor. Furthermore, there are fewer moving parts, and wear is negligible, owing to the copious oil supply. The oil circuits are self-draining, and damage from oil locks is impossible. Volume control is effected by means of a modulating suction valve, permitting the compressor to be regulated without the use of large-capacity receivers, while the starting characteristics are such that squirrel-cage motors can safely be used with star-delta starting.

MINIATURE HIGH-POWER MICROSCOPE

Primarily designed for research and general-purpose work, but with a wide range of application in industrial investigations, the McArthur microscope, announced by McArthur Microscopes Limited, of London, W.1, is of completely revolutionary design. Despite the fact that it is about the size of a miniature camera, measuring only $4 \times 2\frac{1}{2} \times 2$ in., and weighing only 18 oz, it utilizes standard eyepieces and objectives and a standard tube-length, has a range of magnification between $\times 25$ and $\times 1500$, and yields an image identical in quality with that of the largest conventional optical microscope. Furthermore, its portability renders it particularly appropriate for field work, while its rigid construction from a single rectangular block of metal enables it to be used with the highest powers in the hand, even in a moving vehicle or under conditions of vibration.

The microscope carries three standard Cooke objectives, including oil-immersion, and a standard eyepiece. A conventional condenser with iris is employed, while a special prismatic system provides the necessary tube-length and contributes to the reduced dimensions and weight of the whole instrument. The optical principle is simple: Light enters the instrument from above, either by a mirror from an external source, or directly via a built-in illuminator. The beam of light passes vertically downwards through the condenser to the object, and thence through the upwardly directed objective. It is then reflected horizontally along the base of the microscope, and finally upwards through the eyepiece. This



inversion of the stage of the microscope provides a number of important advantages. Thus, for example, the image is direct, instead of inverted, as in conventional instruments. Furthermore, the slide lies face downwards on the stage, so that all normal specimens are held in the plane of the stage and are unaffected by slide thickness, and consequently focusing becomes automatic, even with the high powers.

The three parfocal objectives, a wide range of which is available, are mounted in a straight line on a sliding plate and, as they are in practically permanent adjustment, with only a small degree of fine adjustment to compensate for different specimen thicknesses, there can be an immediate interchange of different series of such objectives. Moreover, since the objectives are always in focus, condensers can also always be in focus, and, in this connection, there is a series of condensers available, including a 2-lens Abbé, a dry achromat, an oil-immersion achromat, and an oil-immersion dark-ground condenser, each of which can be accurately and permanently centered and prefocused, so as to be in immediate adjustment as soon as it is dropped into place.

A full range of accessories is available, all intended for easy and efficient mounting on the standard basic instrument, and includes photomicrographic equipment, gliding stage, binocular eyepiece tube, and polarizing equipment.

WELDED STEEL PRESSURE CAPSULES

In place of the more traditional copper alloys hitherto used because of their ease of soldering or brazing, spring steel, stainless steels, and the Nimonic alloys are, as the result of the development of new production techniques, now being used by Kelvin & Hughes Ltd., of Barkingside, Essex, in the manufacture of pressure capsules. In this way, the limitations of copper capsules have been very largely overcome.

Among other advantages derived from the use of these new capsules, with their welded steel diaphragms, are lower hysteresis; the ability to use corrosion-resistant materials; higher sensitivity and overload capacity; improved joint strength, permitting higher differential pressures to be withstood; considerably increased working temperatures; and flangeless construction, with a consequent reduction of waste space.

RELAY ASSEMBLY KIT FOR EXPERIMENTAL PURPOSES

An interesting solution to the problem of obtaining "one-off" relays for experimental or development purposes is provided by a special relay kit produced by Stevenage Relays Limited, of Stevenage, Herts. This kit makes it possible to assemble rapidly and easily a particular relay to satisfy a given set of conditions, so that it can be subjected to experiments and modified, if necessary, and then reassembled until a design of production standard has been evolved. In short, the kit enables development engineers to be versatile in their use of relays and to continue projects without unnecessary delays.

Basically, the kit comprises seven different relay coils, complete with yokes and armatures, and a selection of stacks designed to cover most possible applications. Half of these stacks have light-duty silver contacts, and the other half heavy-duty Elkonite. All the light-duty stacks are change-overs, thus permitting their use as makes and breaks. Included with the stacks is a suitable variety of screws and buffer blocks, while, to assist in assembly and setting, a suitable screwdriver and box spanner, together with a pair of relay-setting pliers, are

still undecided?

Indecision is not an uncommon failing. Indeed, many of us in one direction or another will continue to dither, even when faced with indisputable facts.

For instance, it may be perfectly obvious that the tapping screw offers many advantages over the conventional machine screw ; that it eliminates costly thread cutting operations all along the production line ; that it ensures easier assembly ; that for joining metal, wood or plastic, it is stronger, cheaper and faster.

Such facts being recognised and accepted, that the tapping screw makes a stronger, swifter, cheaper, easier, safer and better-looking product — in any material, there seems but one course of action. You're right. Change over to tapping screws ! Still undecided !

LINREAD LTD · COX ST · BIRMINGHAM 3

Linread

SLOTTED AND PHILLIPS RECESSED HEAD MACHINE SCREWS AND TAPPING SCREWS • HIGH TENSILE HEXAGON HEAD BOLTS AND SETSCREWS
AIRCRAFT BOLTS, SCREWS AND RIVETS • SEMS • RIVNUTS • CUSTOM DESIGNED COLD FORGED FASTENERS • ALEX SCREWPLUGS

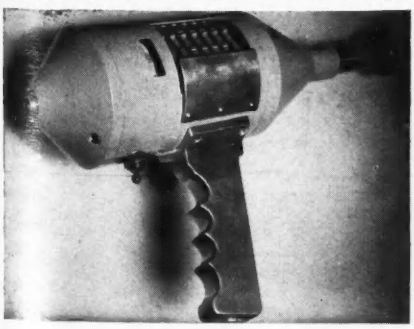
supplied. In addition, a booklet is furnished with the kit, giving guidance in the assembly and design of relays, so as to avoid the incorporation in equipment of relays which are so marginal as to be unrepeatable in bulk production.

By means of this kit, prototype test equipment can be "bread-boarded" on the spot, and demonstration equipment can easily be made by selection of appropriate coil and stack arrangements, the only delay in producing a "one-off" relay being the time required to assemble and set the contacts.

PORTABLE LOVIBOND COLORIMETER

Intended for use wherever surface colours are to be matched and recorded in figures, a new compact colorimeter, shown at the recent Physical Society Exhibition, London, is announced by The Tintometer Limited, of Salisbury. Designated the Lovibond Hand Tintometer, the new instrument enables exact records of colour changes to be kept with any type of surface colour, and is especially useful in applications where the sample cannot be taken to the laboratory for tests, but must be examined on the spot.

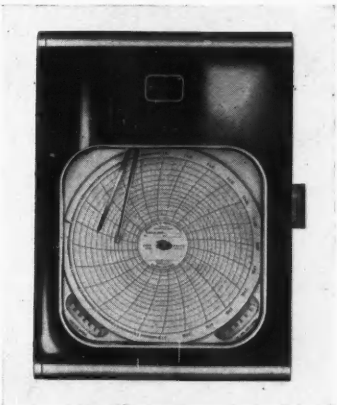
The colorimeter basically consists of a machined aluminium casting with a pistol-type handle, and a suitable selection of Lovibond glass slides in rotatable discs, each of which contains up to nine colour standards. Three krypton-filled lamps inside the instrument illuminate the sample and also a reference surface of white magnesium oxide, so that, when the operator looks through the eyepiece, a circular field, divided vertically, is seen, one division being the colour under examination, and the other the white standard background, with glasses interposed, as desired. In addition, a special rotatable colour-wheel is provided, this being fitted with neutral-tint glasses which can, if required, be superimposed over the sample if it is too bright to be matched directly. With experience, it is possible to repeat results with very satisfactory regularity. From the readings obtained, the original colour can be reconstructed at any time, enabling comparisons to be made with other samples or with the same sample.



The instrument, which operates on 12 V, is supplied complete with a carrying case, in which is fitted a transformer, so that it may be plugged into the mains. A roll of magnesium ribbon is included, for recoating the white background with magnesium oxide.

HIGH-STABILITY WIDE-BAND PNEUMATIC CONTROLLER

Featuring high stability of control action, without loss of sensitivity, coupled with a wide proportional band, the new Series 500 controller announced by The Bristol Company, of Waterbury, Conn., is eminently suitable for measuring and controlling such variables as pressure, vacuum, temperature, liquid level, flow, differential pressure, and mechanical motion. Control modes available include narrow-band (on-off), proportional, reset, derivative, and reset plus derivative. Models for cascade, selective, and ratio control, as well as for programme control, are also available.



Design features of the new controller are wide proportional band width ($\frac{1}{2}$ to 400%), with easy shift in width, full zero derivative setting on the triple-mode controller, reset-action stops for prolonged deviation from set point under severe load changes, easy reversal of action, and a precision linkage arrangement, permitting complete disassembly and recalibration with only one adjustment.

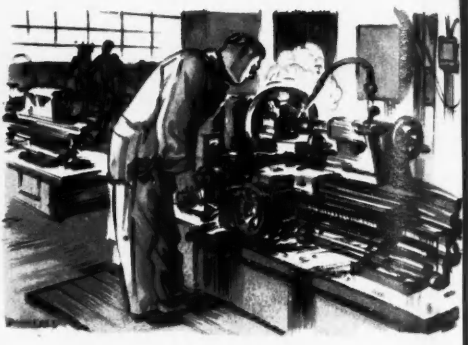
PORTABLE PHASE-SEQUENCE INDICATOR

Designed for checking polyphase instruments, alternators, motors, etc., to ensure that they are connected correctly, the new portable phase-sequence indicator announced by The English Electric Company Limited, of Stafford, is of compact construction, weighing only 14 oz complete with leather case. Basically, the instrument is a simple induction motor, with a conventional three-phase

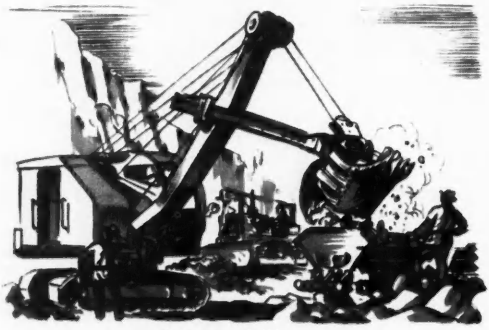
ERRATUM

On page 177 of our issue of April 1957, our description of the E.M.I. Electro-Oculographic Eye-Movement Measuring Apparatus erroneously stated that the eye voltages concerned are of the order of 0·0005 microvolt. This figure should have been 25 microvolts.

Iron and Steel Rolling



Machine Tools



Contractors' Plant

Generating Sets

TWW

Wherever you see this sign it means *big* business

IRON & STEEL · NON-FERROUS METALS · TRACTORS & EARTH MOVING PLANT · EXCAVATORS & CRANES RAILS & SIDINGS · SHIPBREAKING · FOUNDRY PLANT & SUPPLIES · CONTRACTORS' PLANT & EQUIPMENT PLANT & MACHINERY · STRUCTURAL STEELWORK **FACTORY PLANNING & INSTALLATION.**

INDUSTRIAL PLANT · ROADSTONE & ROADSURFACING GRANITE & FREESTONE · CEMENT · INDUSTRIAL DISMANTLING · WIRE & WIRE PRODUCTS · NUTS & BOLTS · PACKINGS & JOINTINGS · INSULATING MATERIALS · FOOD PREPARING MACHINERY **RUBBER PRESSINGS & PRODUCTS.**

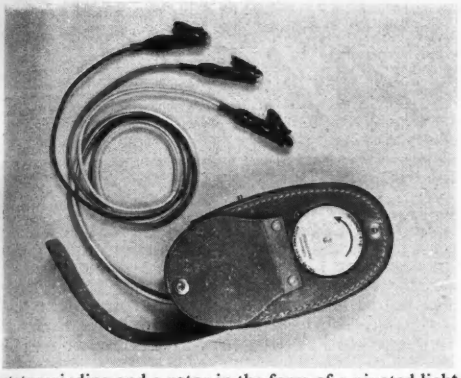
Send now for a current copy of The Albion Machinery Catalogue —a comprehensive stock list of new and second-hand plant and machinery including Machine Tools, Contractors' Plant, Generating Sets, Pumps and Compressors. It is brought up to date and reprinted at regular intervals.

SERVING INDUSTRY AROUND THE WORLD

THOS. W. WARD LTD

Dept: E ALBION WORKS · SHEFFIELD

London Office: BRETTENHAM HOUSE · LANCASTER PLACE · STRAND · LONDON W.C.2.

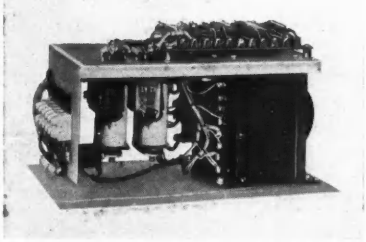


stator winding and a rotor in the form of a pivoted light-alloy disc. When the leads are connected in the sequence red, yellow, and blue, the disc, clearly marked with an arrow, revolves in the conventional anticlockwise direction.

Robust leads, 3 ft in length, are led from the plastic case of the instrument through a transparent protective sleeve and terminate in strong insulated spring clips, designed to protect the operator when making connections. The indicator can remain in its case when in use, the dial being exposed by folding back a small flap. The leads are accessible through an additional flap at the bottom of the case. Rated at 50 to 600 V at 20 to 400 cps, the instrument, which can easily be carried in the pocket, can be left in circuit for 30 sec at the highest voltage.

MINIATURE A.C. AUTOMATIC TAP CHANGERS

Providing an inexpensive, compact, and reliable method of bringing widely varying mains voltages within limits acceptable for most types of electronic and electrically powered equipment, the new miniature a.c. automatic tap changers announced by Claude Lyons Ltd., of Hoddesdon, Herts., are so designed that the output voltage always remains within $\pm$ 5% of the declared value for input variations as high as $-$ 20% to + 10%, thereby covering all likely fluctuations in mains voltage.



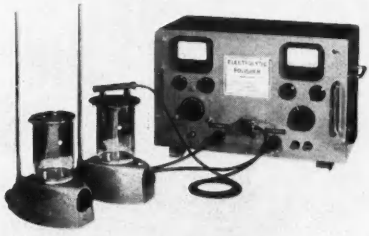
These tap-changing transformers are provided with three output taps, the appropriate tap to be used being selected by two relay-operated microswitches. The relays are operated by an electronic sensor unit, which compares a rectified sample of the input voltage with a stable reference voltage produced by a miniature voltage-regulator valve. The output waveform is free from distortion, while the accuracy of control is unaffected by wide frequency variations (45 to 65 cps) and is fully maintained from no-load to full load. Efficiency is high, power consumption being only about 15 W.

These tap changers are made in two basic sizes, rated at 2½ and 5 A for voltages between 200 and 250 V, and 5 and 10 A for voltages between 100 and 125 V. All types are available as chassis or as convenient complete units. A range of accessory transformers greatly increases their usefulness. The illustration shows an uncased model, suitable for incorporation into existing equipment. Installation is extremely simple, consisting merely of screwing the baseplate of the unit, which is mounted by four bolts only, to the chassis of the equipment.

ELECTROLYTIC POLISHER FOR METALLOGRAPHIC SPECIMENS

Simple and flexible in use, and designed to ensure reliable trouble-free operation, a new electrolytic polisher for metallographic specimens, developed by Nash and Thompson Limited, of Chessington, Surrey, comprises a free-standing magnetic-stirrer assembly and a control cabinet containing the necessary electrical equipment for producing a highly smoothed d.c. voltage across the electrodes.

Provision is made for connecting one or two magnetic stirrers to the front of the cabinet, stirring speed being regulated by means of a control knob mounted in the base of each. Each stirrer accepts a standard 1000-ml



beaker, one containing the electrolyte and the other water for washing the specimen immediately after polishing. On the top rim of the electrolytic beaker is fitted a moulded polythene cap containing the two electrodes, which take the form of quick-release clips. This electrode cap is connected to the cabinet by a flexible cable and can be very quickly transferred to the washing-water beaker at the end of the polishing cycle, thus minimizing the possibility of unwanted chemical etching or staining of the specimen. This very flexible arrangement lends itself to very efficient operation, as it is possible to replace the electrolyte beaker with another extremely quickly, so that a number of different metals can be polished by several operators using the instrument in quick rotation.

In addition to electrolytic polishing, the apparatus can be used for other processes requiring a d.c. potential, e.g., in laboratory-scale investigations of electroplating and anodizing techniques.

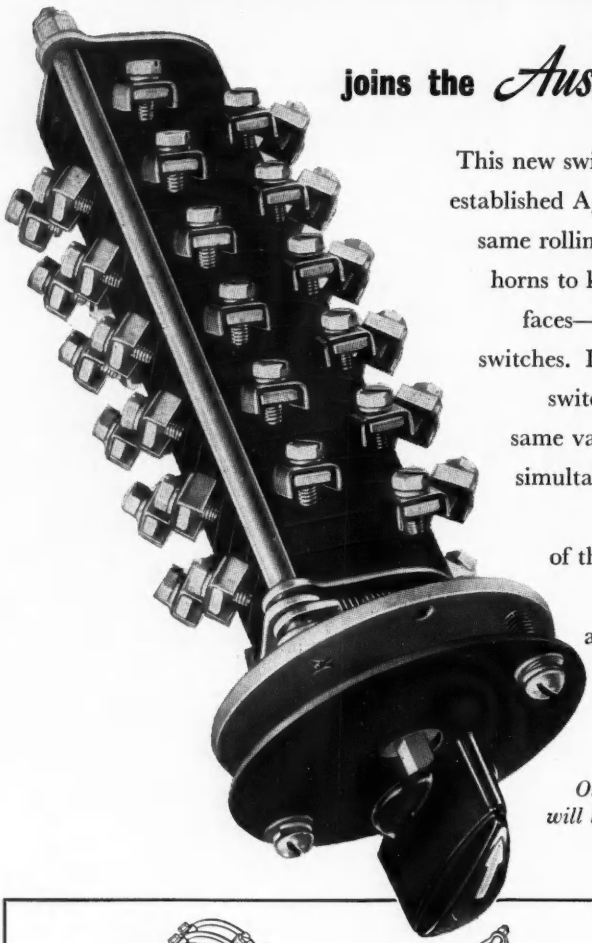
New Torque-Meter with Dynamometer Ring

(*Concluded from page 208*)

meter unit, and the slip-rings do not have to be mounted inside the unit, as shown in Fig. 2, but can be fitted at one end of the drive, if desired.

With regard to dynamic behaviour, this torque-measuring unit, depending on size and the materials used, has a natural frequency between 100 and 2500 cps in torsion, and a bending frequency between 1200 and 3500 cps. If required, even higher natural or resonant frequencies can be obtained by using particularly rigid rings. The dynamometer can be used to determine values of transmission torque with an accuracy of $\pm$ 2% but, if special precautions are taken during testing, it is possible to achieve an accuracy of $\pm$ 0·5%.

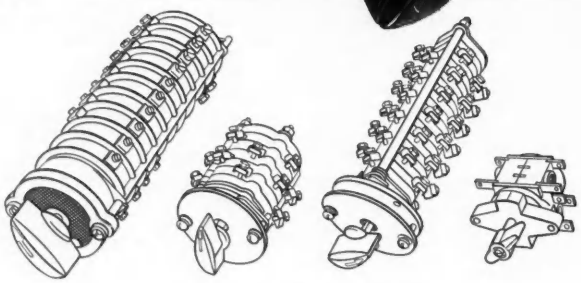
Now the A15—



joins the *Austinlite* rotary switches

This new switch is identical in principle to the well established A50 and A30 rotary switches. It has the same rolling, self-cleaning contacts with extended horns to keep any arcing away from the contact faces—a feature exclusive to Austinlite rotary switches. It has a similarly powerful and positive switch mechanism, and can be built in the same variety of forms to switch in sequence or simultaneously very large numbers of circuits. It is extremely compact, the smallest of the Austinlite multi-cell rotary switches. It bridges the gap between the A30 and the little single-cell 10-amp switch. Delivery, on standard applications, can now be made in four weeks.

Our brochure "SIMPLIFIED SWITCHING" will tell you more about the advantages of Austinlite Rotary Switches. May we send you a copy?



The four Austinlite Rotary Switches—A50, A30, A15 and A10

Austinlite

ROTARY SWITCHES

tailor-made by

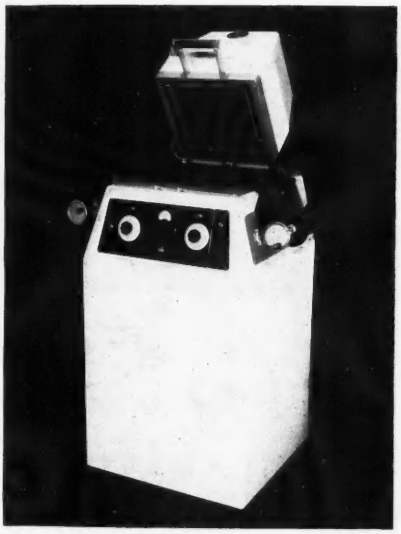
STONE-CHANCE LTD.

(Makers of Sumo Pumps and Stone-Chance lighthouses). Crawley, Sussex

INSTRUMENTS, ELECTRONICS & AUTOMATION EXHIBITION

Promoted by five British Trade Associations and showing the products of some 200 British manufacturers, the Instruments, Electronics, & Automation Exhibition was held between May 7 and 17, 1957, at Olympia, London. A small selection from the many items shown at this Exhibition is reviewed in the following pages.

An interesting item of equipment, among others exhibited by **Cinema Television Ltd.**, is their electronic photographic printer, designed principally to overcome the high-intensity variations existing in negatives produced by aerial photography. These variations are caused both by the camera and by the illumination of the field, as well as by reflectances of the scene, obliques, cloud shadows, etc., and can be as high as 1·5, or even, in extreme cases such as night negatives, up to 2·0. Owing to the inability of printing paper to reproduce faithfully the full range of densities present in the negative, the amount of information obtained from the print is therefore severely restricted, unless these variations are equalized.



The new equipment is basically a contact printer, but the light-source used is a cathode-ray tube, on which is produced a single spot of light, which is made to scan out a rectangular raster, in the same way as a television picture. The light is projected onto the negative by a suitable optical system, so that each small area of the negative is illuminated in sequence by the moving spot of light. The amount of light transmitted through the negative and printing paper, which are in contact with one another, will naturally vary in accordance with the density variations of the negative, and this quantity of light is collected by a photo-electric cell positioned in an integrating cube. The output from the cell is amplified and fed back, to control the brightness of the spot of light on the cathode-ray tube, so that it decreases in intensity as the less dense areas of the negative are scanned. In this way, the effects of negative-density variations can be reduced to any desired value by control of the degree of feedback employed. The complete equipment is constructed in console form and employs a vertically mounted cathode-ray tube, on which is reproduced a raster, $\frac{1}{2}$ in. square, projected by a suitable lens to fill a 10 × 8 in. printing plane at a working height of approximately 3 ft. A glass plate, 12 in. square and 3/16 in. thick, is recessed into the working top of the console and is supported on two sides by a spring mounting, so that even pressure is maintained between the negative and the paper and another glass plate fitted to the hinged integrating cube forming the top of the console. The photo-electric cell used is an eleven-stage multiplier with a flat-ended cathode of 1·75 in. diameter.

Electronic batch counters making use of Dekatron tubes are being extensively used in control engineering, and exhibits from **Elcontrol** included a new batch counter of this type. The standard unit incorporates up to four counting stages and can be provided with a variety of input stages for picking up photo-electric signals, signals from external high-speed switches, externally generated pulses, etc. The basic unit can be supplied in forms suitable for use as a batch counter, a process timer, and a time-measuring instrument.

By making use of a recently introduced miniature photo-cell, Elcontrol are now producing a completely new range of photo-switches. The most important characteristic of these switches, which were also exhibited, is the extremely small size of the photo-head, which is housed in a cylindrical aluminium fitting only $\frac{3}{4}$ in. in diameter and 3 in. in length. The associated relay unit is also considerably reduced in size, measuring approximately $7\frac{1}{2} \times 5\frac{3}{4} \times 5$ in. Despite its small size, however, the chassis is fully withdrawable, thus greatly facilitating servicing and installation. These new units are particularly suitable for use where limited viewing space is available and where a high degree of discrimination is required. For example, it is becoming increasingly common to use this type of equipment for checking the presence of the workpiece before operating a multiple press, and conversely to check the presence of a tool, e.g., a broken drill on a multiple drilling machine. An additional feature of great practical importance is that, with this type of unit, the viewing head can be connected by up to about 80 ft of cable from the amplifying unit.

Other Elcontrol exhibits included two versions of their latest automatic control units, type FSD2, for gas-oil burners controlled by temperature or pressure, and a range of proximity switches for the level control of free-flowing solids and non-conductive liquids.

Among other items, a new range of transistor-type electronic controllers was exhibited by **Kelvin & Hughes Ltd.** Employing a sensitive moving-coil microammeter in the measuring section, these instruments can be applied to any process in which the variable to be measured and controlled can be converted into a millivolt output. Its principal application, however, is in conjunction with a thermocouple or resistance thermometer for the measurement and control of temperature. Two-position, three-position, and proportional controllers are available.

A new system of automatic ultrasonic testing, whereby precise ultrasonic testing can be carried out at high speed by automatic methods, was also demonstrated. Designated "Autosonics", this equipment overcomes many of the limitations of manual ultrasonic inspection, and provides a number of important advantages. Thus, a large volume of material can now be inspected rapidly at predetermined standards as part of a production line, while a series of stable electronic circuits provides for the operation of automatic alarms when defects are encoun-

It can't be done without CONTROL

Ruling the waves has been something of a habit of Britannia's for longer than we care to remember —birthplace of the Plimsoll line, the steam turbine, and Lloyd's standards of construction, it is only fitting that our maritime nation should come up with the latest and greatest aid to man's mastery of the ocean, the Radar screen. But this wonderful aid to seamanship is of no value if the complicated control mechanism involved is unreliable or inaccurate. Control of anything, for that matter, must be reliable. The kind of efficient control that Magnetic Valves exercise, automatically or remotely, over air, steam, coal gas, oil or most other industrial liquids or gases. No glands, no stuffing boxes, no driving shafts either, but lots and lots (over 25 years) of experience built into them. Details of the standard range are available in our illustrated literature. Special valves up to 12 in. orifice can be supplied.

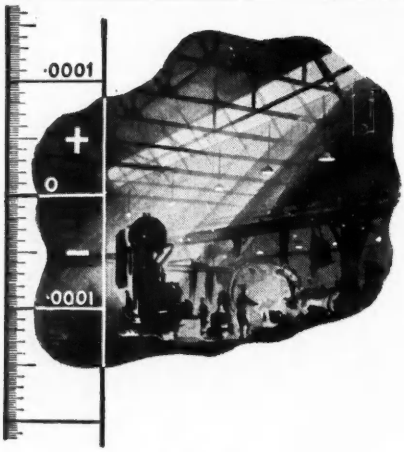
Many valves available ex stock.

Valves designed for special conditions.

THE MAGNETIC " R " TYPE SINGLE BEAT STOP VALVE

The standard valve is provided with ¼ in., ⅜ in. or ½ in. B.S.P.T. Connections and $^{9}/_{32}$ in. orifice ($^{5}/_{32}$ in. seat diameter) to operate on pressures up to 100 lbs. per square inch. An increased size orifice can be arranged dependent upon the pressure to be controlled. This valve is suitable for controlling water, air, oil, gas, refrigerants, etc., and is adaptable to either straight or angle pattern.

the Magnetic Valve Company LIMITED 28 ST. JAMES'S PLACE, LONDON, S.W.1. Tel. HYDe Park 7581



Progress depends on

PRECISION

Greater productivity is only possible when the precision and accuracy of all jigs, fixtures and gauges are of the highest order. The modern specially laid out shops of G.P.A., allied to the finest standards of workmanship constitute your guarantee. We welcome your enquiries.

GPA

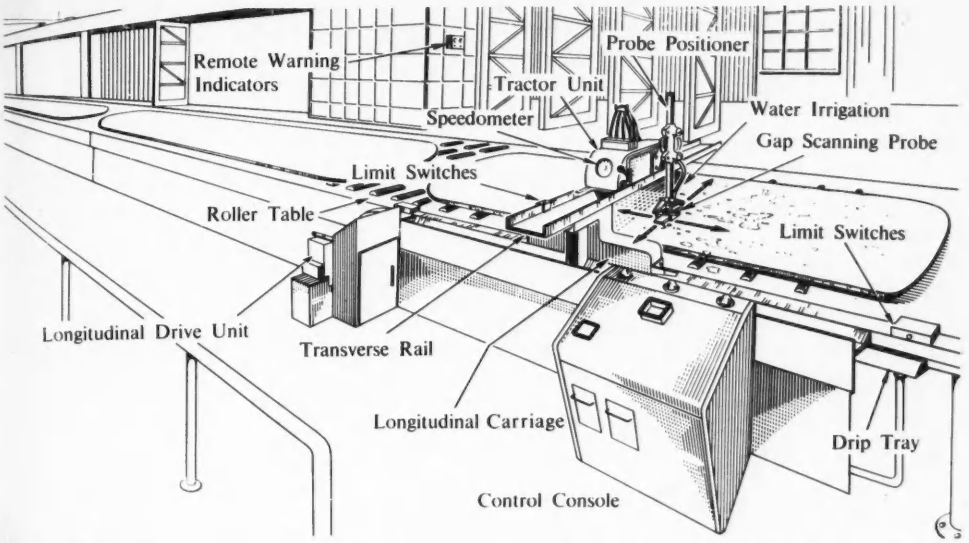
G.P.A. TOOLS & GAUGES LTD.

CONTROLLED BY SALFORD ELECTRICAL INSTRUMENTS LTD, A SUBSIDIARY OF THE GENERAL ELECTRIC CO, LTD.

Registered Office and Works :

HARPER ROAD, WYTHENSHAWE, MANCHESTER **Tel. WYTHENSHAWE 2215 (3 lines)**

Grams: Pneutools. Phone Manchester.



tered. The ultrasonic waves generated are transmitted into the material as a sequence of energy pulses by an inspection probe coupled to the surface of the material by a liquid, the complete sequence of events being shown on the screen of a cathode-ray tube. The automatic flaw alarm and recorder section operates visual or aural signals, etc. when a flaw indication is obtained on the screen, and can be adjusted to respond to indications from defect signals in any section or only to signals from separate narrow strata which can be set anywhere in the cross-section. Sensitivity can be adjusted so that it will respond to small or large indications, and the output from this section can be used to operate various recording systems, e.g., to provide a plan-position indication of any defect present in a plate.

In the event of the selected monitor signal falling below its control level for any reason, an alarm will operate and will stop the scanning machinery, remaining in operation until the fault is corrected, after which it can be reset. An important feature of the Autosonics equipment is that a predetermined scan or search plan is accurately followed by the probe system, thus ensuring that all information relevant to position and size of the defect in the specimen is indicated and recorded. Selection of the type of scan and recorder is governed by the nature and position of the probable defects, the dimensions and shape of the specimen, and production conditions. The illustration shows a diagrammatic impression of an installation for the automatic detection of laminations in steel plate by a gap-testing technique.

A wide variety of equipment was exhibited by **Evershed and Vignoles Ltd.**, ranging from a typical control desk for the process industries and equipment for combustion control and chemical analysis down to "Megger" testing sets and a thickness gauge no larger than a pencil. New products included the Evershed electronic process controller Mark 4, Tinsley polarographs, an Evershed miniature recorder Mark 2, a Megger low-resistance testing set (I.S.) Series 1, a simple computer, and a precision tank-gauge transmitter.

Of these items, the new computer is a simple analogue computing device which provides a continuous and instantaneous solution of algebraic equations occurring in the day-to-day operation of process controllers, boiler-control schemes, gas- or fuel-flow systems, etc. The input information to the computer is an electrical signal which requires no programming or processing, and the output of suitable transducers, measuring devices, or manually controlled signal sources may be introduced directly as variables into the input to the computer. Similarly, the output i.e., the mathematical evaluation according to a predetermined formula of the variables and constants, can be employed directly as an operating signal for electro-mechanical control mechanisms, etc. It can also be displayed on indicating and recording instruments, if required. The computer may be completely integrated into a process-control scheme, evaluating continuously the variables and constants entering into the controlled process, and its output used to maintain the process in a desired manner. Alternatively, it may be used purely for display of the solution of algebraic equations of dynamic problems.

Of the other new exhibits, the Evershed precision tank-gauge transmitter (illustrated) is intended for automatic gauging where measurement of interface level is required to the same accuracy as that of surface level. With this device, an accuracy of $\pm 0{\cdot}1$ in. is obtained, and all submergence errors caused by friction have been overcome by removing all loading from the level-sensing device, and by servo-operating the dial reading mechanism, so that the instrument is sensitive even to minute changes in the level being measured.

PRECISION PERFORMANCE No. 1

the bat knows what he's at

THERE are no bats in the bat's belfry. Just a natural sort of radar. Sounds normally indistinguishable to the human ear are emitted from the bat's mouth and, echoing back from surrounding objects, give him the clue to his whereabouts. So although *Rhinolophus Hipposideros*, the bat, does not see very well he can fly through the gathering darkness without touching so much as a twig. Such accuracy is matched, in another sphere, by Dunlop engineering components, which are designed to give a calculated performance in a wide variety of industrial applications. Produced in rubber compounds of controlled elasticity or rigidity, they include bonded-to-metal anti-vibration mountings and flexible power-transmission couplings which are available in standard ranges. Special components in natural and synthetic rubbers can also be produced to a given specification. For advice in this field consult Dunlop Engineering Components Division.

DUNLOP ENGINEERING COMPONENTS

● SPECIALISTS IN PRECISION RUBBER ENGINEERING

DUNLOP RUBBER CO. LTD. (ENGINEERING COMPONENTS DIVISION) FORT DUNLOP, ERDINGTON, BIRMINGHAM 24

75PC/PC4

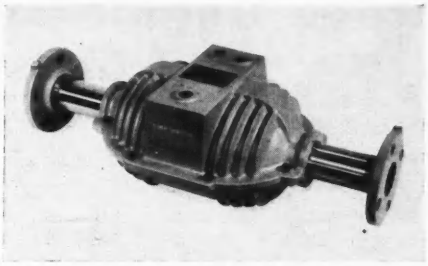
In addition to their comprehensive range of Commander-class instrumentation, including the recently introduced Commander KE self-balancing electronic temperature recorder, **George Kent Ltd.** exhibited their new synchronous converter (illustrated), which is basically a single-pole double-throw switch, operating continuously at mains frequency, and which is designed primarily for converting small direct currents into proportional alternating signals for easy drift-free amplification. It can also be used for the phase-sensitive rectification of small alternating currents or for both purposes simultaneously, e.g., in chopper-type d.c. amplifiers.

In this converter, a soft-iron armature, carried on a beryllium-copper reed, is vibrated at mains frequency by the combined action of a permanent magnet and an energizing coil. Contacts attached to the reed engage with two others, mounted on light flexible blades and preloaded inwards against adjustable stops, thus eliminating contact bounce and enabling the " make " periods to be preadjusted independently to any setting. Four standard settings are available, and the converter is available for operation on mains frequencies of 40, 50, and 60 cps, construction differing only in the thickness of the central reed. Spurious effects are minimized by a combination of design features. Magnetic e.m.f. is kept well below 1 μV by means of a Mumetal shield around

the coil, together with small and balanced internal circuit loops. Thermal e.m.f. is held to a similar level by a careful choice of materials, combined with a low coil dissipation which reduces temperature gradients. Connection to the coil is by way of a separate plug and socket on the top of the unit, the coil being wound on a metal bobbin which screens it thoroughly from the contact members. These features combine to keep stray currents below about 10^{-11} A and render the converter very suitable for use in high-impedance circuits. Two additional contacts are provided, and these may be used to increase conversion efficiency at higher voltages, e.g., in rectifying circuits. The converter is protected by a dustproof can and fits a standard international octal socket. A retaining clamp is also available.

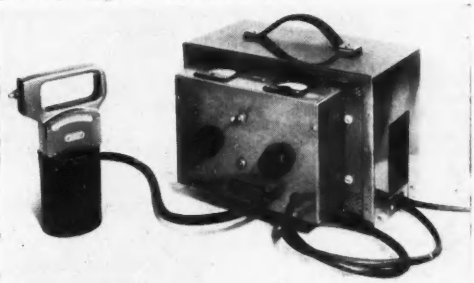
A comprehensive range of process-control instruments and automatic systems, covering variables such as temperature, pressure, vacuum, flow, level, humidity, liquid density, conductivity, capacity, and *p*H value, was exhibited by **Foxboro-Yoxall Limited.** The display featured indicators, recorders, controllers, transmitters, and their related sensing elements in different mountings, including their new type-13A differential-pressure cell transmitter, a pneumatic temperature transmitter, and electronic " Dynalogs " with elements.

A new magnetic flow-meter designed for fluids with electrical conductivity, such as corrosive acids, rayon viscose, sewage, rock and acid slurries, sand and water slurries, paper-pulp stock, etc., was also exhibited. This flow-meter (illustrated) comprises a transmitter and a Dynalog flow receiver, which may be an indicator, a



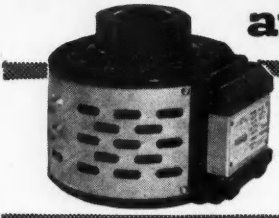
recorder, etc. The flow scale is uniformly linear, and the meter has a range of 100 to 1. The transmitter consists of a stainless-steel tube through which the liquid passes, an electrical insulating liner on the inside of the tube, an electromagnet which induces a magnetic field across the tube, and two metallic electrodes which are essentially flush with the inside surface of the tube. The transmitters are available in line sizes from 2 to 8 in., suitable for flow rates between 0 and 2500 gpm, and 0 and 40,000 gpm. The measurement of reversing flows is easily obtained, and a totalizer may be included, either locally or remotely, to give flow totals in any desired units. The meter has no restrictions of the flow line, no loss of head, and no pressure taps, so that fluids are measured with sustained accuracy.

Among their comprehensive range of equipment, an interesting exhibit from the Instrument Division of **Associated Automation Ltd.** was the steel-plate thickness meter illustrated. This portable instrument is capable of measuring the thickness, from one side only, of steel plates up to 0·25 in., with an accuracy of 5% of scale reading or 0·003 in., whichever is the greater, accuracy being unaffected by surface unevenness, corrosion, paint films, etc. up to 0·015 in. The standard meter may be used with curved plates and pipes of 3 in. diameter or larger, if the material thickness does not exceed 0·25 in., although tests have shown that the meter can be adapted for use with pipes of diameters less than 3 in. The meter can also be used for erosion comparison of metal thicknesesses exceeding 0·25 in. The equipment comprises a measuring head, a control-box, and a battery, the control-box being externally mounted on the battery case. The measuring head is placed on the sample, a push switch in the handle is operated, and a meter reading taken when the pointer comes to rest, a comparison of the meter reading and a calibration curve showing the plate thickness. This calibration curve is provided for use on mild steel ; if other materials are used, another curve must be plotted, using the material concerned.



Another exhibit from Associated Automation Ltd. was their microhardness tester, providing a method similar to the Vickers test. This instrument is supplied to fit a bench-type metallurgical microscope and is suitable for carrying out indentation or scratch tests with a 136-deg. pyramid indenter.

Voltage Regulating Transformers and Line Voltage Regulators



from 250 - 580 VA Models 41 and 42

* *Universal fixing centres*
* *Choice of ganged or automatic models*

THE NEW MODELS 71, 72 from 1.5 to 2.5 KVA

Self-aligning brush gear
(PATENT PENDING)

* *Universal fixing centres*
* *Choice of ganged or automatic models*

BERCO

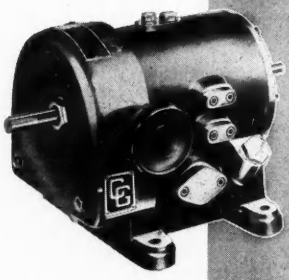
Details available from:—
THE BRITISH ELECTRIC RESISTANCE CO. Ltd
Queensway · Enfield · Middlesex *Telephone : HOWard 241*
Telegrams : Vitrohm, Enfield BR 13

Variable Speed Drives

FOR EVERY INDUSTRY

Carter Variable Speed Gears are available for powers from 0·25 H.P. up to 35 H.P. Together with British Standard motors and, where required, output Reduction Gears they form efficient and compact variable speed drives.

WRITE FOR FOLDER 657



CARTER hydraulic

INFINITELY VARIABLE SPEED GEARS

★ *Infinitely Variable Speed Range.*
★ *Hand, Electrical Remote or Lever Controls.*
★ *Controls may be adjusted with drive RUNNING or STATIONARY.*
★ *Loads may be picked up from ZERO r.p.m.*

CARTER GEARS LTD. **BRADFORD 3, YORKSHIRE,** **Telephone: Bradford 64378/9**
Telegrams: 'Became' Bradford, Telex.

NEWS OF THE MONTH

PERSONAL

Mr. L. M. Broadway has been elected Deputy Chairman to the board of C. C. Wakefield & Co. Ltd. He will hold this office in conjunction with his position as Managing Director. Mr. Broadway, who runs the expanding Wakefield Group of twenty-one companies, was promoted to the board in 1947 and has been Managing Director since 1954.

Messrs. Alfred Holt & Co., Liverpool, announce that following the retirement of **Mr. A. G. Arnold,** after forty-three years' service with the company they have appointed **Mr. J. B. Peacock, B.Sc. (Eng.), A.M.I.Mech.E., M.I.E.E., M.I.Mar.E.,** as Chief Superintendent Engineer.

Mr. Harold Peters has been appointed the new Exeter area superintendent of the A.E.I. Lamp and Lighting Company Ltd.

The General Council of the Combustion Engineering Association have appointed the following to hold office for the official year 1957–8:— President, **Mr. H. C. Hawkins, A.M.I.Mech.E., M.Inst.E.** (B.X. Plastics Ltd.); Vice-Presidents, **Sir John Charrington** (Charrington, Gardner, Locket & Co. Ltd.), **Mr. B. Samuels, M.I.Mech.E., Sir Percy Sanders, C.B.E., D.L., J.P., A.M.I.Mech.E.** (Association of Shell Boilermakers), **Mr. E. W. Thompson, J.P., M.A.** (John Thompson Ltd.); Chairman of the Council, **Mr. L. N. Horne, F.Inst.F., M.Inst.T.** (Charrington, Gardner, Locket & Co. Ltd.); Honorary Treasurer, **Mr. E. W. Barnes, M.Inst.F., A.M.Inst.B.E.** (Riley (I.C.) Products Ltd.).

Mr. T. O. Orr has been appointed Sales Manager to Air Pumps Ltd., and will operate from the company's world sales department at 8 Francis Street, Westminster, S.W.1. Mr. Orr recently resigned from Sumo Pumps Ltd.

Councillor W. G. Pallett, J.P., F.C.W.A. has accepted an appointment as Managing Director of Brayshaw Furnaces & Tools Ltd., Manchester 12, and he has taken up his duties immediately. Mr. Pallett is a member of the Sheffield City Council and was until recently Managing Director of the Laycock Engineering Co. Ltd., Sheffield. From the beginning of April, **Mr. W. T. C. Roden** took the position of Technical General Manager of Brayshaw Furnaces & Tools Ltd.

Mr. Stanley N. Loosen has been appointed Sales Director of The Anti-Attrition Metal Co. Ltd., the non-ferrous founders and engineers at Maidenhead, Berkshire.

Mr. S. W. Perkins, Special Director and Manager of the Factored Machine Division, Wickman Ltd., has been appointed to the board of the company. **Mr. J. W. Buchanan,** who has reached retiring age relinquishes his appointment. He first joined the company in 1930 as London Area Manager, being appointed to the board in 1940. He was then for many years in charge of the company's export business and in this connection travelled widely overseas. For the past twelve years he has been a member of the Council of the Machine Tool Trades Association and served on the committees responsible for organizing the 1948 and 1952 Machine Tool Exhibitions. Since relinquishing executive office with Wickman Limited in 1955, Mr. Buchanan has served the company in a consultative capacity.

Associated Electrical Industries Limited announce that Dr. **J. N. Aldington** and **Sir Nicholas Cayzer, Bart.,** have been elected Directors of the company.

Thermodare (Great Britain), of 94–98 Petty France, London, W.1, the United Kingdom sales subsidiary of Unidare Ltd., announce that they have just appointed **Mr. R. J. Francis** Manager of their Infra-Red Heating Division. Mr. Francis has had many years' practical experience of Infra-Red heating and has been responsible for some of the largest installations in the south of England. For the time being, in addition to his activities as Manager of the Thermodare Infra-Red Heating Division, he will also be looking after the south-east of England for all Thermodare products.

Mr. A. S. C. Chattey has been appointed Chairman of A.C.V. Sales Ltd. and **Mr. P. Rackham,** Home Sales Manager, has also been appointed a director of that Company. Mr. Chattey has been invited to join the board of the parent company, Associated Commercial Vehicles Ltd.

Mr. J. D. Morton, B.Sc., M.I.Mech.E., M.I.E.E., National President of the Association of Mining Electrical and Mining Mechanical Engineers has been appointed Managing Director of Siemens-Schuckert (Great Britain) Ltd., following the retirement of **Mr. A. E. Barton, M.B.E., M.I.Mech.E.**

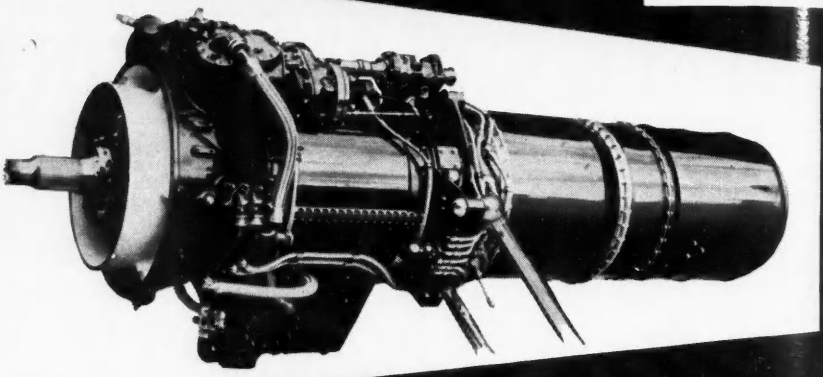
Norton Grinding Wheel Company Limited announce that **Mr. J. C. Ewer,** will shortly be leaving them to take up a new appointment in Norton Company, U.S.A. Mr. Ewer, who has been with the Norton organization now for more than twenty years, was transferred to N.G.W. in 1950. In July of the following year he was appointed Managing Director and his six years of office have seen a steady growth in the range of Norton products made in this country and in their total turnover. Changes of appointments following his departure will be announced by Mr. A. Donald Kelso. President of Norton Behr-Manning Overseas Inc., at the annual general meeting of N.G.W. which will be held early in May.

Cable and Wireless Ltd. announce that **Mr. A. H. Harris, A.M.I.E.E.,** has been appointed Deputy Engineer-in-Chief of the company as from 1st April. He succeeds **Mr. C. J. V. Lawson, M.I.E.E., M.I.R.E.,** who on that day takes office as Engineer-in-Chief in succession to **Mr. J. A. Smale, C.B.E., A.F.C., B.Sc., M.I.E.E.,** who retires after thirty-eight years' service.

Expandite Limited announce the promotion of **Mr. R. T. Richey** to Area Manager, Motor Industry Division, and **Mr. P. A. Tennant,** Area Manager, Eastern Counties. Both have been technical representatives with the company for a number of years.

Mr. S. G. Marshall has been appointed Manager of the machine shop at the Belfast Works of Short Brothers & Harland Limited. Mr. Marshall first joined Shorts in 1941 when he worked in the Aerodynamics Department, at Rochester. In 1953 he became Assistant Project Engineer on Comet production and was later appointed Britannia Project Engineer with responsibility for the build-up of Britannia production at Belfast.

Mr. F. Gordon Kay, of the Acheson Organization left on 5th April for an extended tour of overseas markets. After spending one week in New York he will proceed to Brazil and then visit each of the other major countries in the South American Continent where "dag" dispersions of colloidal graphite and molybdenum disulphide are finding a growing market. It is expected that during the trip Mr. Kay will cover between 22,000 and 24,000 miles by air.

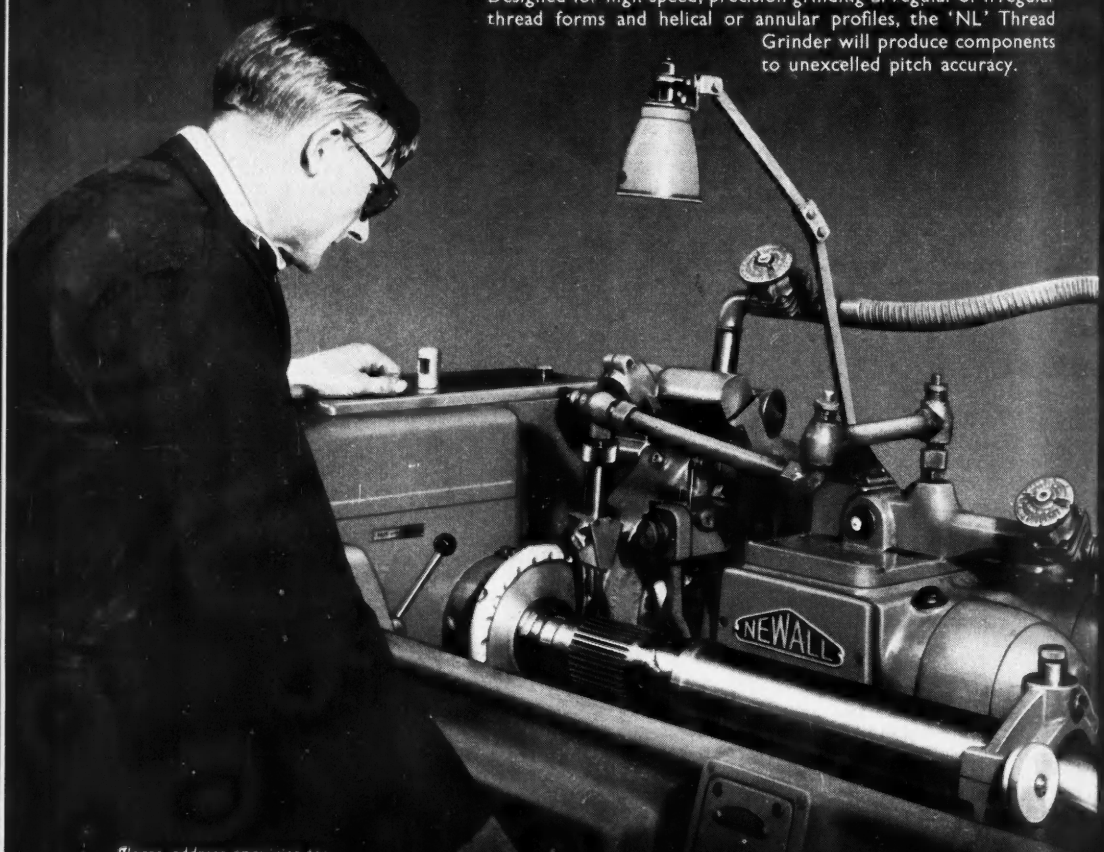


NEWALL

NL THREAD GRINDER

Vital threads in the production of **ARMSTRONG SIDDELEY 'MAMBA'** turboprop power units are ground on Newall 'NL' Thread Grinding Machines.

Designed for high-speed, precision grinding of regular or irregular thread forms and helical or annular profiles, the 'NL' Thread Grinder will produce components to unexcelled pitch accuracy.



Please address enquiries to:

NEWALL GROUP SALES LTD PETERBOROUGH

TELEPHONE: PETERBOROUGH 3227-8-9

BUSINESS NEWS

An Agreement has recently been made between Lodge Plugs, Limited, who manufacture "Sintox" material at their works in Rugby, and English Steel Tool Corporation Ltd., Openshaw, Manchester (a wholly owned subsidiary of English Steel Corporation Ltd., Sheffield) whereby the distribution of "Sintox" Cutting Tools in the United Kingdom is now to be undertaken exclusively by English Steel Tool Corporation Ltd.

The telephone number of the **Honeywell-Brown Ltd.**, Middlesbrough office is now stated to be Middlesbrough 44331/3 and not as shown in our April issue.

A new joint company, **Davy British Oxygen Limited**, has been formed which will make available to the Steel Industry "oxy-steel" processes utilising the steel plant manufacturing resources of **Davy and United Engineering Co. Ltd.**, Sheffield, and the metallurgical techniques and tonnage oxygen plant manufacturing facilities of **British Oxygen Engineering Ltd.** and **British Oxygen Linde Ltd.**

Following the recent statement that the **Baldwin Instrument Co. Ltd.** had joined the Group of Companies controlled by **C. E. Harper Aircraft Co. Ltd.** it is now announced that the present range of Baldwin products will be continued with increasing emphasis on industrial application of nucleonics, electronics and fluid power equipment. Over the next four years, manufacturing facilities will be considerably expanded as will research and development. They will continue to operate as a separate company but will be supported by the larger resources of the Harper Group.

Marconi's Wireless Telegraph Co. Ltd., have supplied the first industrial television equipment to the **National Coal Board** which is being used experimentally at the Manvers Coal Preparation Plant at Wath-on-Dearne, where it has been installed as an aid to plant control.

An exchange of technical knowledge on liquid fuel rocket engines—primarily those using high test peroxide—will result from an agreement signed by the **Aerojet-General Corporation** of the United States and **D. Napier and Son Ltd.**, of Acton, London.

Extensive alterations have commenced at the Newcastle Branch premises of **Simms Motor Units Ltd.** An additional building adjacent to the existing premises has been acquired which is being completely rebuilt internally and when completed will house a new diesel department equipped with the most up-to-date machines for the servicing of fuel injection equipment. Enlargement of the present electrical repair department and stores will also be carried out at the same time. The second floor of the new building will be occupied by two of the Simms Group Companies—**Industrial Fan & Heater Co. Ltd.**, of Birmingham and **R. F. Landon & Partners Ltd.**, of Kingsway, London—as their Northern Area Offices and Service Depot.

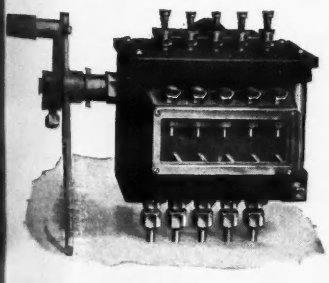
Monks & Crane Ltd., distributors of engineers' small tools, recently announced in their development programme the inauguration of a Machine Tool Division. This expansion has sprung from the recognition of a world-wide market for British and Continental Machines. At Garretts Green Lane, the Company's Head Office in Birmingham, a large proportion of the new contemporary showroom accommodates an excellent display of machines for drilling, shaping, milling, turning, grinding and cutter grinding and arrangements will be gladly made for demonstrations on request.

The First Year Book of the **Federation of Engineering Design Consultants**, has been published, some ten months after the Federation's formation. This is a comprehensive reference book containing the fullest details of the Federation's member firms, technical scope, qualifications, specialist fields, experience and many other details which will be of interest to manufacturers who avail themselves of the services of engineering design consultants. Technical and geographical indices are included for convenient reference. Copies of the Year Book 1957 are available upon application to the General Secretary, The Federation of Engineering Design Consultants, St. Stephen's House, Westminster, S.W.1. Price: 5*s*.

Previously located at 16 Hockley Street, Birmingham, the cable sales office and warehouse of **Standard Telephones and Cables Limited** was moved to larger premises at 48 Kenyon Street, Birmingham on Monday, the 29th April. Under the management of Mr. N. F. Abbott, the new depot will carry complete stocks of all types of Standard rubber and plastic cables.

From April 1, 1957, the Technical Sales and Service Department of the **Acheson Colloids Ltd.** have moved to 70 Hill Street, Richmond, Surrey. Telephone RIChmond 2066 and 2634. The move, which has been necessitated by the continued expansion of the sale of "dag" products, will enable the department to provide better and speedier service. The Accounting Section will remain at 18 Pall Mall. All future orders should be sent to the Richmond address and enquiries for Technical Sales and Service to Richmond or the nearest area Sales Office at 79 Church Road, Moseley, Birmingham, 13. Telephone: South 2676 or Champness Building, Drake Street, Rochdale, Lancs. Telephone: Rochdale 48667.

The Lincoln Electric Co. Ltd., commenced manufacture of their products in a small single-storey factory at Welwyn Garden City, Herts, in August 1935. Now, in 1957, they celebrate their 21st Anniversary. During these 21 years the continual expansion of the Company's activities has necessitated several factory extensions, until, finally, the position has been reached where further enlargement of the factory was not practicable. A completely new factory which was commenced in February 1956, has now been built and is to be officially opened on the 22nd May, 1957.



Empire Engineering Co. (Manchester) Ltd.

High Class Brassfinishers and General Engineers

Makers of:—

Relief Valves for Compressed Air Units, Air Receivers, Steam Lines, etc. Steam Driers, Oil Separators, Hand Pumps.

Mechanical Lubricators for Diesel Engines, Oil Engines, Steam Engines, Air Compressors, Conveyors, etc. Displacement Lubricators for Steam Engines and Air Lines.

Empire Works, Clarendon Road, SALFORD, 5, Lancs.

Telegrams: Appliances, Phone, Manchester Telephone: PENdleton 2339

CONSOLIDATED PNEUMATIC MAKE OVER 480 DIFFERENT MODELS OF POWER TOOLS

IT IS THE QUIETEST AIR-POWERED SCREWDRIVER IN THE WORLD!

This is the C.P. SUPERSONIC SCREWDRIVER

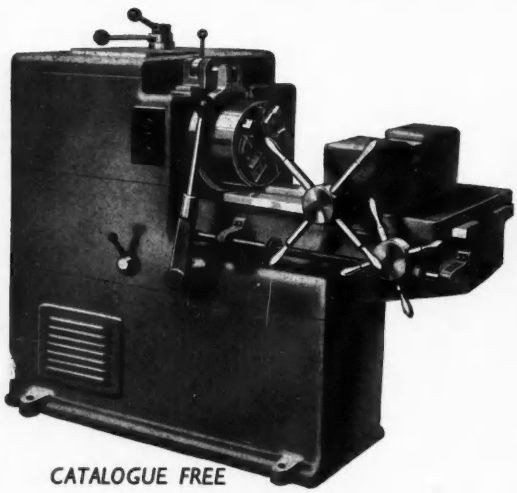
The C.P.—3008 screwdriver is a really effective step forward in overcoming production and assembly shop noise. It has a supersonic exhaust—the exhaust sound waves have been raised to a frequency higher than that audible to the human ear. Other efficiency features are—clutch, adjustable without the use of tools ; built-in speed control ; directional exhaust ; all steel construction ; weight less than 2 lb. ; length only 9 inches ; full line of accessories. Write SP426 on a postcard for full details.

Consolidated Pneumatic

AIR COMPRESSORS
PNEUMATIC TOOLS
ELECTRIC TOOLS
CONTRACTORS EQUIPMENT
ROCK DRILLS · PUMPS
DIAMOND DRILLS

CONSOLIDATED PNEUMATIC TOOL CO. LTD.,
232 Dawes Road, London, S.W.6

CP184



CATALOGUE FREE ON REQUEST

HEAP'S PATENT AUTOMATIC SCREWING MACHINES WITH ROTARY TANGENTIAL DIE HEADS

These machines have been especially designed for quantity production work, and they are capable of extremely fast rates of output. Outstanding features include Tangential Die Head, Hand and Automatic Releasing Motion, Automatic Closing Device, Automatic Pump, etc.

A full range of sizes are available

JOSHUA HEAP & CO., LTD.
ASHTON-UNDER-LYNE · ENGLAND

INDUSTRIAL PRODUCTS

A general duty, ¼ in. capacity, two-speed portable electric drill has now been made available by **Wolf Electric Tools Limited,** of London, W.5. The introduction of this machine will enable users to perform ¼ in. (high speed), and ½ in. (low speed) drilling operations in metal at the correct cutting speeds and with the minimum of effort. One advantage with this machine with its dual function is that when drilling deep ½ in. diameter holes in hard materials, extremely high penetration speeds can be obtained by drilling a ¼ in. diameter pilot hole before boring out to the required diameter.

The Consolidated Pneumatic Tool Company Ltd., of London, S.W.6, have recently introduced a Core Box Vibrator which operates at 9,000 vibrations per minute and can free cores up to 3,000 lb in less than 90 seconds. The unit weighs 34 lb and may be clamped on to the cleats of the inverted core box, the clamp jaw grips being adjustable between 3 in. and 7 in. With the extremely high rate of vibration and absence of heavy sledging of the core boxes many advantages are reported, such as reduced operator fatigue, undamaged cleats and boxes, elimination of trowelling time resulting in increased core output and core boxes which remain " true ", thus reducing core or casting rejects.

Broadway Equipment Ltd., of London, N.W.3, have recently been appointed Sole Agents in the United Kingdom for the " Hufel " electrically driven single and multi-spindle screw assembling and spin riveting machines for small electrical and similar components. These machines are very suitable for high quantity production and can be delivered with 3 phase or single phase capacitor-start motors.

A new propeller brake weighing only 24 oz. will be among the exhibits of the Aviation Division of the **Dunlop Rubber Co. Ltd.,** at the 22nd Salon International de Aeronautique. It has been designed to stop propellers rotating as soon as possible after landing, allowing a marked reduction in " turn round " time.

A.E.I. Lamp and Lighting Company Ltd., of London, W.C.2, announces the introduction of a new flameproof fluorescent fitting. Designed for safe operation in atmospheres where inflammable vapours and explosive gases may be present, the fitting is fully Buxton certified and approved for use in Group II and III inflammable gases. This covers most industrial situations, including those in the petro-chemical industries.

Following the recent additions to their range, the **Supaslot Angle Co. (G.B.) Ltd.,** of London, W.1, now announce an improvement in the design of Supaslot Major 14 and Supaslot Major 12 gauge angles. Whilst retaining all the advantages of fixing and adjustability, the new design gives even greater strength which has been made possible by replacing the 45° slot with a hole on the inner edge and an angled transverse slot on the outer edge of the large flange. With this arrangement there is an added advantage in that positive location can be obtained at every 1½ in. instead of every 3 in.

Three new electrodes which are suitable for either A.C. or D.C. supply have been added to the range manufactured by **Quasi-Arc Limited,** of Bilston, Staffordshire. Ferroloid No. 3 electrodes are a development in the 55/45 Nickel-Iron class and are intended especially for strength welding of ordinary grey and special duty cast iron. Chromoid No. 4 electrodes, of particular interest to chemical engineering and oil refining industries, deposit weld metal of 18/8/3 Chromium-Nickel-Molybdenum composition stabilized with Niobium, and they conform to the requirements of I.C.I. Specification No. M.154G, Class E.

Australite Limited, of Crawley, Sussex, announce the introduction of a new Rotary Switch, the type A.15, which is an extension of their existing range. In spite of its compactness, the switch is liberally rated at 15 A 250 V, or alternatively, 7½ A 440 V. Also, it is suitable for direct-on-line starting of 3-phase induction motors up to 5 hp.

New Publications recently issued by the **English Electric Co. Ltd.,** of Stafford, include numbers SG/238, Oil-Filled Outdoor Current-Transformers, SG/240, Indoor Current-Transformers, WA/135, Stainees Electrodes and SG/337, Medium Voltage Air-Break Switchgear.

A booklet entitled " Workshop Auxiliary Equipment ", issued by **The British Thomson-Houston Co. Ltd.,** of Rugby, includes interesting information on electrical, mechanical and electronic aids to productivity, the equipments described being of the kind frequently needed by the works engineer when planning industrial installations.

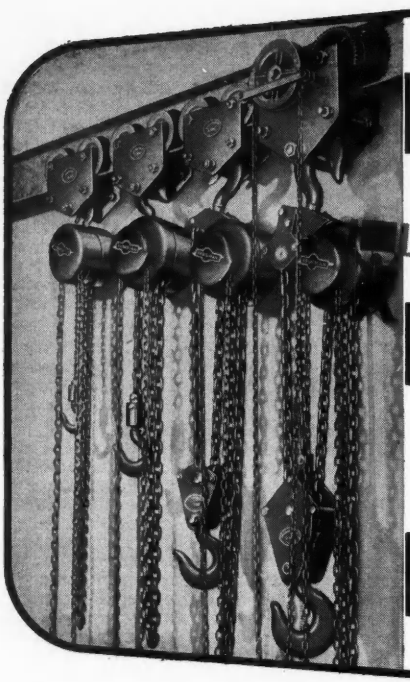
A new booklet entitled " Terylene for filtration " has just been published by **Imperial Chemical Industries Ltd.,** Fibres Division, Hookstone Road, Harrogate, Yorkshire.

Desoutter Brothers Ltd., of London, N.W.9, have recently introduced four new silent pneumatic screwdrivers. The noise usually associated with these tools has now been reduced to such a low pitch that large numbers of them can be operated simultaneously without causing the slightest annoyance to the operators. These new models are available in a range of four different speeds; each one being designed for a specific purpose. The slow speed models by virtue of greater reduction gearing give higher torques where they are most required. Accessories include screwdriver bits for all types of screws with either slotted or cruciform heads and a wide range of box spanners for nutrunning. In addition, hexagon bits can be supplied for driving socket-headed cap screws and special spoke nipple bits are available for cycle wheels.

Venner Electronics Limited, of New Malden, Surrey, have just produced two types of transistorized amplifier. The first, TS3, is intended for industrial applications and has a response within 3 db from 15 c/s to 125 kc/s; the second, TS4, is intended for frequencies in the audio range and has a response flat within 3 db from 120 c/s to 10 kc/s. The voltage gains of the amplifiers are similar, being between 900 and 1000. Each consists of two stages which may be used separately or in cascade, the individual stage gains being of the order of 60. The Amplifiers are assembled in plastic cases and are mounted on small 8-pin bases. The pin connections are identical. The units are small and lightweight, Amplifier TS3 being 1⅛ in. × 1⅞ in. × ⅝ in. and weighing ⅞ oz; Amplifier TS4 being 1⅝ in. × 2⅜ in. × ⅞in. and weighing 1½ oz.

The first miniature fluorescent indicator lamp produced in this country in colour, is now being marketed by **Hivac Limited,** the sub-miniature valve specialists of South Ruislip. The lamps are designed to meet the growing demand for an alternative colour to the standard neon. At present they are only being produced in green, but other colours may possibly become available in the future. Having the advantage of a negligible power consumption and absence of heat, they have numerous applications both in industry and the domestic appliance field.

An important licensing agreement which provides for the future manufacture of automatic machine tool control components has been concluded between **The Plessey Company Limited,** of Ilford, and **Farrand Controls Inc.,** of New York. Under the agreement, Plessey will develop in this country during the next two years, applications for the existing Farrand system of electronic machine tool control. The basis of the Farrand system is a position control element known as the Linear Inductosyn which comprises a scale and slider allowing positional accuracy of better than ·0001 in. with a repeatability of approximately 25 micro inches.



No more manhandling when you have installed

Vaughan

TYPE A47
PULLEY BLOCKS

Totally Enclosed : Lightweight : Hard wearing
Capacities : ½, 1, 2, 3, 5 TONS

Phone EAST 2771 *for Ex-stock dispatch!*

THE VAUGHAN CRANE CO. LTD.
MANCHESTER 12 :: ENGLAND

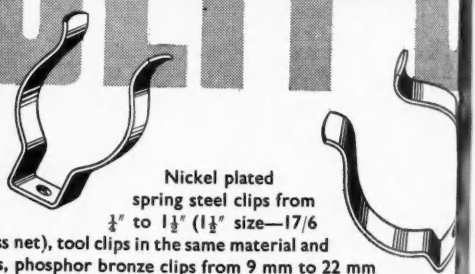
Makers of fine pulley blocks
for over half a century.

SPECIAL COCKS
FOR THE
ENGINEERING & MOTOR TRADES

Wm. Whitehouse & Co. Ltd..
BRUETON ST • BIRMINGHAM 4
Telephone ASTON CROSS 2451

CLIPS

SPRING STEEL
PHOSPHOR BRONZE



Nickel plated spring steel clips from ¼" to 1½" (1½" size—17/6 gross net), tool clips in the same material and sizes, phosphor bronze clips from 9 mm to 22 mm —say when ! There are lots of variations on the same theme if it isn't in stock we can soon make it. Better get in t with Lewis of Redditch today.

LEAVE IT TO
Lewis
OF REDDITCH
SPRINGS, SPRING CLIPS
PRESSWORK, WIRE FORMS
VOLUTE SPRINGS

A 2/6d postal order will brin our 40-page booklet on s design, full of technical and just the thing for your d department.

THE LEWIS SPRING CO.
RESILIENT WORKS, REDDI
Phone: Redditch 720/1/2
London Office: 122 High Holborn,
Phone: Holborn 7479 & 74

CONTRACTS

The General Electric Co. Ltd. is the contractor for the power equipment of the five high-speed diesel-electric train sets which are being designed and built by the **Metropolitan-Cammel Carriage & Wagon Co. Ltd.,** in Birmingham, for service in the London Midland and Western Regions of British Railways.

The British Thomson-Houston Co. Ltd., has received contracts valued at nearly £1,000,000 from **British Transport Commission,** covering switchgear and high-speed circuit breakers required for the electrification of Kent Coast lines of the Southern Region of British Railways.

The Free Piston Engine Co. Ltd., a member of the **Associated British Engineering** group, announces that it has been awarded a contract by the **Singapore City Council** to supply free piston engined power for an electric generating station in Singapore City. This is the largest single order for free piston machinery that has so far been placed anywhere in the world. It is also the first British manufactured free piston gasifyer to be sold abroad. The present contract, which is in excess of £1,500,000, concerns the replacement of the previous steam plant at St. James power station, and is for an installation giving a total output of 36,000 kW, made up of six sets of 6000 kW each. Each set consists of eight GS.34 gasifyers of 100 hp each, driving an exhaust gas turbine and direct coupled alternator. The first 6000 kW unit is scheduled to come into operation in mid-summer, 1959, and the full 36,000 kW will be in operation early in 1960. The GS.34 unit is of the same type as that manufactured by the French company **SIGMA:** such units have been in operation at Cherbourg for a considerable time in the daily service of Electricité de France. The turbines and alternators will be supplied by **Cie. Electro Mécanique (C.E.M.).** The Free Piston Engine Co. Ltd., submitted their tender for this contract to the London Consultants to the Singapore City Council, **Messrs. Preece, Cardew and Rider.**

J. & H. McLaren Limited. of Leeds, have won a $124,000 order from an American company for the supply of power plant for micro-wave telecommunications equipment in Canada. This will be followed by orders for more than a quarter of a million dollars for additional equipment for an extended scheme. This order was secured by McLarens—a member of the Brush Group—despite keen American competition. The order has been obtained from the Montreal factory of the **Radio Corporation of America.** It is for diesel electric equipment required to provide a continuous source of supply to radio apparatus for a wireless telegraphy scheme in the Province of Manitoba.

Heenan & Froude Limited of Worcester, have received an order from the **Royal Dutch Airlines** for a Heenan torque-reaction hangar stand for testing Rolls-Royce Dart engines and also 5000 hp Allison Turbo Prop. engines. The plant will be supplied with all accessories and will be installed in one of the two existing test houses at Schiphol Airport, where two cable suspended hangar stands—supplied by Heenan & Froude—are in operation. For some time the cable suspended plants will also remain in use for testing piston engines. It is expected that the torque-reaction plant will be in operation early next year.

A contract for the construction of the second stage of the foundations at High Marnham Power Station, Nottinghamshire, has been awarded by the **Central Electricity Authority** to **Taylor Woodrow Construction Ltd.,** who are already engaged on the first stage. Taylor Woodrow's contract there now comprises the whole of the main foundations and circulating water works for the station's boiler and turbine plant, producing 1000 megawatts of power from five 200 megawatt turbo alternator sets. The work, valued in all at £4,250,000, is expected to be completed in the summer of 1961.

EXHIBITIONS AND MEETINGS

A new 16 mm colour film of 20 minutes duration entitled " Air Controlled " was shown for the first time on Wednesday 8th May, to an invited audience and the trade and local press, by **Benton & Stone Ltd.,** of Aston Brook Street, Birmingham 6, at the Midland Hotel, Birmingham. The film covers a wide field of activities from shots in their own Works and that of Geo. H. Hughes Ltd., in Birmingham, to examples in a modern bottling plant, a well-known car factory, an instrument works, and an ironworks slag-handling plant, etc. There was also an exhibition of some examples of the latest pneumatic equipment of their manufacture and that of Geo. H. Hughes Ltd., of Birmingham, who manufacture the British Bellows products under licence from the Bellows Company of Akron, Ohio, U.S.A.

An **Electronic Computer Exhibition,** to include data handling equipment of all kinds, is to be held at Olympia, London, from November 28 to December 4, 1958. The Exhibition will be the first of its kind to be held in Great Britain. It is being sponsored, at the suggestion of the National Research Development Corporation, by a joint committee of the Radio Communication and Electronic Engineering Association and the Office Appliance and Business Equipment Trades Association under Mr. J. A. Cumming, chairman of the Exhibition Committee of O.A.B.E.T.A. The Radio Communication and Electronic Engineering Association recently formed a Data Processing Section and most of the leading firms concerned in both Associations have already indicated their intention to exhibit. A joint Exhibition Organizing Committee representing the two associations has been set up under the chairmanship of Mr. V. M. Roberts, a member of the Council of R.C.E.E.A. and Chairman of its publicity committee, with Mr. A. G. Coaten, a member of O.A.B.E.T.A., as Vice-Chairman. Mrs. S. S. Elliott, Exhibition Director of O.A.B.E.T.A., has been appointed Organizer and Mr. J. F. Richardson, Technical Secretary of R.C.E.E.A., is secretary of the Committee. Enquiries should be addressed to him at the Radio Communication and Electronic Engineering Association, 11 Green Street, London, W.1.

NEW BALL & ROLLER BEARINGS

OVER 4,000,000 IN STOCK
IN MORE THAN 4,000 TYPES

BRITAIN'S LARGEST STOCKS

STOCK LIST AVAILABLE

CLAUDE RYE BEARINGS

895-921 FULHAM ROAD, LONDON, S.W.6
Renown 6174 (Ext. 24) Cables: Rybearings, London Telex 2-3453

Nu-way for *Industrial* OIL FIRING

Write NU-WAY HEATING PLANTS LTD (Box 447) DROITWICH

BACKED BY A QUARTER OF A CENTURY OF LOCKHEED HIGH-PRECISION HYDRAULICS

HYDRAULIC SLAVE CYLINDERS

Expressly made to give long service

Our first consideration in producing Lockheed hydraulic equipment is to ensure long life and reliability, with the minimum of maintenance under the arduous conditions imposed by industrial use, and we put these requirements before initial cost and other factors.

Lockheed slave cylinders are to be found in boiler houses and gas plants throughout Britain, working satisfactorily after ten years without attention. The conditions generally involve heat, cold, fumes and dust.
Among Lockheed features in quality design and manufacture which contribute to this result are

1 Hard-Chrome-Plated Bore
2 Hard-Chrome-Plated Ram
3 Ram Bearing and Piston of adequate length to prevent knuckling when extended
4 Mirror finish on rams and in bore
5 Long life seals of LOCKHEED design
6 Flexible protective boot on ram extension

In addition to the type of cylinder shown, we design many types of cylinder to the individual requirements of customers.

Further particulars of these units will be sent on request—kindly mention this journal.

Our engineers are always at your service to discuss industrial hydraulics.

AUTOMOTIVE PRODUCTS COMPANY LIMITED
SHAW ROAD, SPEKE, LIVERPOOL, 19. Telephone: Hunts Cross 2121

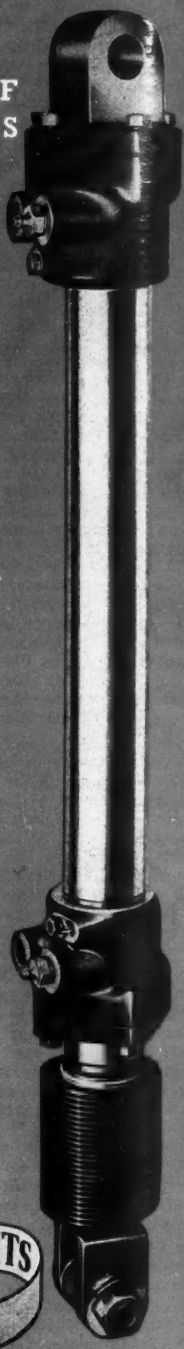
Lockheed

REGD TRADE MARK

INDUSTRIAL HYDRAULICS

BRITISH MADE

COMPLETE INSTALLATIONS OR INDIVIDUAL UNITS



Classified Advertisements

The rate for all classified advertisements is 6d. per word; in bold print 9d. per word; minimum order 6s. Box-number advertisements 1s. extra. Instructions, together with remittance, must be received not later than the 3rd of each month for advertisements to appear in the same month's issue.

SITUATIONS VACANT

Oil Distillers and Refiners, Trafford Park, require young graduate engineer. Alternatively a chartered mechanical engineer. Initially plant maintenance work. Wide scope. Salary according to potential ability. Non-contributory pension scheme in operation. Please address letter to the Personnel Officer, Box No. 208, *The Engineers' Digest*.

WORK WANTED

Cut Wires, Pins, Special Rivets, Formed Wires, Manufactured to Specification by Wire Products and Machine Design Ltd., No. 4, Bridge Road, Haywards Heath, Sussex, Phone 1990.

A. & B. Motors (Newton-Le-Willows) Ltd., Mill Lane, Newton-Le-Willows, Lancashire, England: Accredited Motor Dealers for British Motor Corporation: Jaguar car, Rolls-Royce and Bentley, etc., have an efficient Engineering Department—engaged in the production of repetition machined parts: The work on hand is sub-contract for numerous important establishments. The firm is desirous of taking on the manufacture of an American article from start to finish for sale in Great Britain under licence. They are equipped with modern machinery with go ahead personnel having the know how to turn out a first class job. Capital available and good representation. Bankers reference, Westminster Bank Ltd., Earlstown, Newton-Le-Willows, Lancs. Trade reference, W. Watson & Co. Ltd., Car Distributors, Bold Street, Liverpool. Replies to:—**A. & B. Motors (Newton-Le-Willows) Limited**, Mill Lane, Newton-Le-Willows, Lancs., England.

BUSINESS FOR SALE

Foundry Business for disposal in North Lincolnshire. Suitable for sole trader or as a branch for existing foundry business. For further details apply to the Trustee, S. D. Moore, F.C.A. (Dutton, Moore & Co.), 4 Silver Street, Hull.

BELPER TOOLS

CHAPEL ST., LEVENSHULME, MANCHESTER, 19

PRECISION ENGINEERS

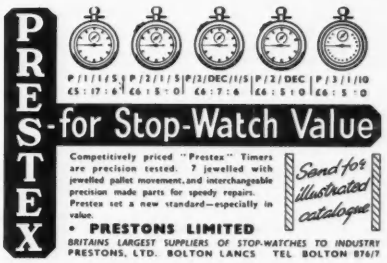
For Milling, Turning, Grinding, etc.

OSMOND

CUTTING OFF MACHINES

A. & S. OSMOND, LTD.
13 DOWRY SQ., BRISTOL

Telephone:
Bristol 27604


PRESTEX
P/1/1/5 £5:17:6
P/2/1/5 £6:5:0
P/3/DEC/1/5 £6:7:6
P/2/DEC £6:5:0
P/3/1/10 £6:5:0
for Stop-Watch Value
Competitively priced "Prestex" Timers are precision tested. 7 jewelled with jewelled pallet movement, and interchangeable precision made parts for speedy repairs. Prestex set a new standard—especially in value.
Send for illustrated catalogue
• PRESTONS LIMITED
BRITAINS LARGEST SUPPLIERS OF STOP-WATCHES TO INDUSTRY
PRESTONS, LTD. BOLTON LANCS TEL BOLTON 876/7

UNIPOWER RZEPPA LIMITED

A BIRFIELD COMPANY

Ignore this advertisement if you want an easy-paced job awaiting dead men's shoes. We have exciting prospects to offer the right men. Unipower Rzeppa is a fairly new member of the energetic Birfield Group of Companies. It has a brilliant product—a really effective constant-velocity universal joint, and Birfield is providing the capital to enable Rzeppa to market this product on a large scale. The Company is moving from Shipley, Yorkshire, to Birmingham to share premises with Hardy Spicer Ltd., so that it will have space to set up modern production lines. To help achieve its ends it needs two first class men who are young and ambitious, educated to at least H.N.C. standard, and who meet the following requirements :

1. MACHINE TOOL DESIGNER.

The man to fill this job must have had first class special purpose machine tool design experience including work on electro-hydraulic controls and auto-cycle machines.

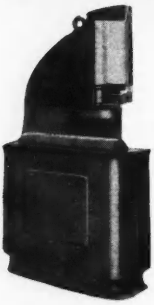
2. UNIVERSAL JOINT DESIGNER.

The initial design development and prototype work on this product has been done. There is, however, a great deal of design work to do in the application of this product to each of its many uses. To take charge of this design work we need a competent young designer who knows that his career lies in producing ideas and translating them into designs and who has good design experience. We would particularly welcome hearing from men with experience in the design of products involving ball-bearings.

In both cases the salary and terms of service will be attractive and for each man, in addition to attractive initial conditions, there will be the opportunity to work hard to earn personal growth which will come with the growth of the Company. Applications should be made in writing to the Personnel Director, Hardy Spicer Ltd., Birch Road, Witton, Birmingham, 6.

PILOT HYDRAULIC POWER PRESSES

HYDRAULIC CROPPING MACHINE



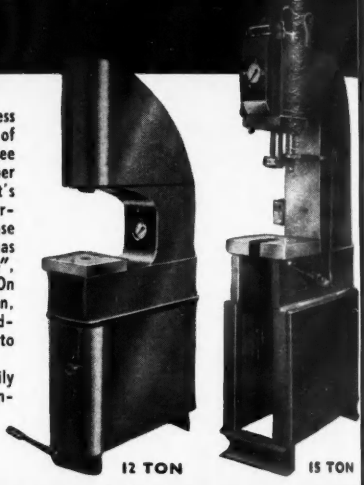
Approximately 3 square feet of floor space only is needed for these amazing Pilot Machines.

The Cropper provides up to 1½ tons for holding the material when cutting ½" mild steel bar and ¼" sheet steel and plate.

The 12 ton Pilot Press has a ram speed of 1⅛" per second free travel with 2½" per second return. Pilot's 15 ton Press is powered by a 4 h.p. 3-phase electric motor and has a daylight of 16¾", power return ram. On the 12 and 15 ton, ram pressures are adjustable from zero to maximum.

All parts are easily accessible for maintenance.

Please send for descriptive leaflet.



12 TON 15 TON

PILOT WORKS LTD MANCHESTER RD BOLTON (Inc M. EDWARDS & SONS)

TEL: BOLTON 5545-3 LINES GRAMS: TIPGEAR BOLTON LONDON: 3 SOUTHAMPTON PLACE WC1 TEL: CHAncery 5130.

P4650

Quality Products

A new type Fire-resistant Hydraulic Fluid

HOUGHTO-SAFE 271

combines the safety of a fire-resistant fluid with outstanding efficiency.

In plants performing Die-casting, Welding, Hot Press Forging and other hydraulic operations near flames or great heat, Houghto-Safe 271 is the solution to a big problem.

HOUGHTO-SAFE IS SAFE and much more besides

Houghto-Safe 271 is reinforced to ensure many other benefits:

- High film strength provides greater protection for metal parts for longer periods.
- Extra service life of equipment.
- No ill-effects on type of packings normally used.
- Houghto-Safe 271 maintains an unusually even viscosity through widely fluctuating temperatures, meaning high performance value—less wear and tear.
- The fluid is pumpable at temperatures down to as low as minus 15 deg. F.

Research Service

Edgar Vaughan & Co. Ltd.

BIRMINGHAM · 4 · ENGLAND

Works and depots at:
BIRMINGHAM · MANCHESTER
LIVERPOOL · SOUTHALL (Middx)
BRISTOL · GLASGOW

BOOKS RECEIVED

Electricity and Magnetism. By J. Newton, B.Sc., A. Inst. P., A.M.I.E.E. 622 pp., 366 illustrations. Publishers : Sir Isaac Pitman & Sons Ltd., Parker Street, Kingsway, London, W.C.2. Price : 25/–.

Covering the Electricity and Magnetism syllabuses of the Advanced level of the General Certificate of Education and the Intermediate examination in Physics, and meeting the requirements of the Ordinary National Certificate in Applied Physics, this authoritative book starts with a study of current electricity, apart from two introductory chapters on electrostatics and magnetism. This order of treatment leads to a more balanced and interesting approach to the subject, without making any sacrifice in the logical development. It avoids placing undue emphasis on electrostatics and magnetism, the detailed consideration of these being deferred until later.

The many fundamental, but often abstract, concepts which are met within a study of electricity are fully explained, since a firm grasp of these is essential to any real understanding of the subject. Information of a more technical character has been included, where appropriate, to assist the reader to appreciate the practical aspects of electrical science. In addition, an introduction to the MKS system of units is given, since a knowledge of this is becoming increasingly necessary.

Protective Painting of Structural Steel. By F. Fancutt, D.Sc., F.R.I.C., A.M.I.Chem.E., and J. C. Hudson, D.Sc., D.I.C., A.R.C.S., F.I.M. 116 pp., 36 illustrations. Publishers : Chapman & Hall Ltd., 37 Essex Street, London, W.C.2. Price : 21/–.

In considering methods of protecting structural steelwork agains atmospheric corrosion by means of paint, used alone or in conjunction with metal coatings, the three major factors governing success or failure are respectively surface preparation, choice of painting scheme, and painting procedure. The results of investigations by the Protective Coatings (Corrosion) Sub-Committee of the British Iron and Steel Research Association, show that the first of these factors is by far the most important, and that correct surface preparation of steel for painting is vital, if successful and economical protection is to be achieved. Maximum duration of protection is obtained by painting over surfaces which have been completely freed from millscale and rust.

These aspects, together with discussions on the choice of paints, and details of the formulations of subsequent and finishing coats, are covered in this new, authoritative, and completely revised book, which has been specially prepared by the writers on behalf of the Sub-Committee. In addition, various other subjects are considered, such as the use of flame-cleaning or of the newly introduced pretreatment primers as a preparation for painting structural steel. Reference is also made to heat-resisting paints and to painting schemes for metal coatings on steel. In short, there can be no doubt that this book is a most useful contribution to all those concerned with the practical problems arising in the protection of steel structures by painting.

Aircraft Hydraulics. *Vol. I : Hydraulic Systems.* Edited by H. G. Conway, M.A., M.I.Mech.E., F.R.Ae.S. 156 pp., 107 illustrations. Publishers : Chapman & Hall Ltd., 37 Essex Street, London, W.C.2. Price : 35/–.

The design, development, and manufacture of hydraulic equipment for modern aircraft represent an important and essential activity of a sizeable section of the industry in every aircraft-producing country. With so rapidly developing a technique it is understandable that there has been a notable lack of a suitable textbook for engineers and students, covering the design and engineering principles of the equipment. This book has thus been produced to fill the gap, covering as adequately as possible the broad principles of hydraulics as applied to this field and giving advice on the design and use of components.

Published under the authority of The Royal Aeronautical Society, this first volume contains well-illustrated and informative chapters (each written by an expert in his own field) on fluids, hydraulic theory (from the standpoint of aircraft systems), general system problems and corresponding circuits, and system-installation and development-testing problems.

Vol. II, to be published later, will discuss component design.

Mechanics. By H. Weiler, Lic. Ès. Sc., Paris, M.Sc., A.S.T.C. 533 pp., 285 illustrations. Publishers : Sir Isaac Pitman & Sons, Ltd., Parker Street, Kingsway, London, W.C.2. Price : 25/–.

Covering all relevant subject matter for the Advanced Level, Scholarship, and Intermediate Examinations in Applied Mathematics, the author of this well-written book has paid particular attention to the logical development of the subject, while the text is sufficiently detailed to be read with ease, if necessary without the assistance of a teacher. The theory is illustrated by a great number of examples, and many exercises and revision questions are included. The revision questions are an essential part of the book, enabling the reader to assess the extent to which he has been able to absorb the theory of each chapter.

A knowledge of calculus, but not of differential equations, is needed, and, in the introductory chapters, proofs are derived from first principles.

Mathematics. By A. T. Starr, M.A., Ph.D., M.I.E.E. 556 pp., 238 illustrations. Publishers : Sir Isaac Pitman & Sons, Ltd., Parker House, Kingsway, London, W.C.2. Price : 45/–.

Written specially to cover the syllabus of Mathematics Parts I & II for the degree of Engineering of the University of London, this excellent book also covers the syllabuses of the Ordinary and Higher National Certificates.

Many examples are worked out in the fields of physics and electrical engineering, and many useful exercises are included. An elementary treatment of operational calculus is given by the method of the Laplace transform, so that students may be able to take advantage of the modern work which prefers this method.

LATEST INDUSTRIAL LITERATURE

1. Data on Steel Tubes and Bars. An excellent pocket diary containing 280 pages of technical data relating to tubes and bars, flanges, fittings and manipulated products has been published by a manufacturer of these products. This booklet presents in compact form the data most commonly required, so as to minimize the number of reference books required in the office. The main headings are extracts from British Standards, standard tolerances, weight lists, steel tables and useful tables.

2. Diesel Engine Inertia Starter. This 2-page leaflet describes a new inertia starter which can easily be fitted in place of the standard electric starter, and turns the engine without any alteration in construction. Turning the cranking handle causes the starter pinion to engage with the flywheel and the engine is slowly rotated through auxiliary gears in the starter, freeing the engine, and priming the injection system. The starter reaches the required speed in ten seconds and a warning bell sounds, indicating that the cranking should cease and a small lever is then moved over to engage the inertia mass in the starter with the pinion, and turns the engine over smartly for about two revolutions.

3. Fans. Two new brochures describing propeller fans and ancillary equipment describe in considerable detail the construction and capabilities of the many models. The fans are of the ring mounting type ranging from 7½ in. to 60 in. diameter and diaphragm mounting type fans from 9 in. to 60 in. diameter, and are available for 50 c/s A.C. or D.C. operation. Special Buxton-tested flameproof A.C. motors and others for saturated atmospheres are also available.

4. Phosphor Bronze. This 10-page catalogue describes the advantages of a specific type of phosphor bronze made by cold-drawing into tubes and round rods. The metal can be provided with a wide range of properties and there are three standard varieties relating to fully annealed, heat treated and hard conditions. In general, similar tools can be employed as for low carbon steel. For rough turning, high speed or hard metal tipped tools are suitable and, for fine turning, hard metal or diamond tipped tools. Rods are available in sizes from about ⅛ in. to 2½ in., and tubes from about ½ in. to 6 in. bore with a maximum wall thickness of approximately ½ in. on the larger sizes.

5. Valves. Two 6-page leaflets illustrate two new control valves now being made in the U.K. under licence from the U.S.A. The first is a two-way normally-closed solenoid operated valve for water, specially designed for a maximum flow capacity in industrial applications where long life and trouble-free operation is a necessity. Suitable for hot or cold water, pressures up to 150 psi, ⅜ in., ½ in., and 1¼ in. pipe sizes it can be adapted to direct switch operation, automatic control, remote control, or time cycle operation, and is designed for continuous duty operation. The second valve has been designed specially for applications requiring a small flow rate of not less than 2/10 gpm or more than 6/10 gpm of water, and is a compact unit consisting of a solenoid valve, flow rate control and inlet strainer. The basic valve is available with or without mounting bosses, and the flow rate control is also optional.

6. Jointings and Packings. In a very well illustrated and informative 128-page book covering a range of Jointings and packings, notes on the correct installation of the products are given at the beginning of each section. A most useful packing recommendation chart is also provided and covers such factors as shaft speed, pressure, temperature, fluid, etc.

7. Internal Grinding Machine. Details have now been issued of an automatic internal grinder designed to achieve a very high level of precision with economy. Robustly built, it is operated by a single lever control after the initial setting up, and it is arranged for both gauge and diamond sizing to increase its scope of employment. Holes from ½ in. to 6 in. diameter can be ground to a maximum depth of 6 in., while the swivelling workhead provides for grinding taper bores up to 60 degrees included angle. Including the control circuit, the grinder is operated entirely by hydraulic pressure fed from a 16 gallon tank by a rotary gear pump powered by a 2 hp motor. The automatic feed may be engaged or disengaged at any time during the grinding cycle.

MAIL THIS COUPON TO-DAY

THE ENGINEERS' DIGEST, 5.57
120 Wigmore Street, London, W.1.

Date.....

Please send free and without obligation the literature indicated by the following circled numbers :

1 2 3 4 5 7

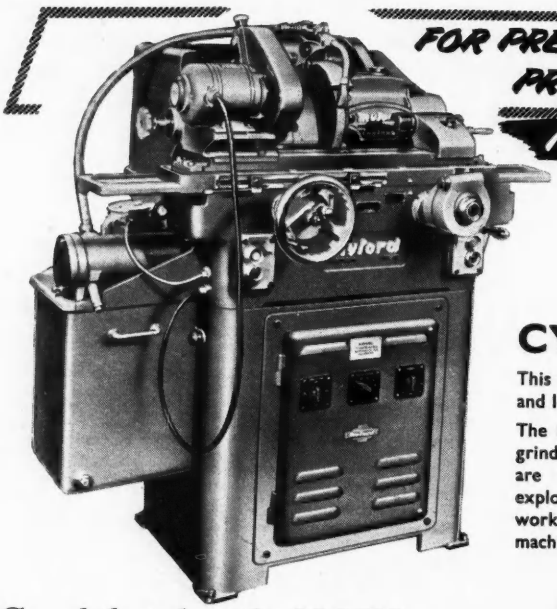
Name .....

Position .....

Company.....

Address .....

HERMETIC RUBBER PRODUCTIONS
To meet every need of Modern Industry in current production or future development.
Our many years of experience as manufacturers in Natural or Synthetic Rubber are at your disposal.
Moulded Products of all kinds, Flexible Fabric Coupling Discs, Extruded Rubber Sections, Radiator Hose (Canvas Inserted), Mud and Stone Deflectors, Mats and Matting.
Est: 1895
HERMETIC RUBBER CO. LTD.
RYLAND STREET . BIRMINGHAM, 16
Telephone: Edgbaston 0983/4
Grams: Hermetic Birmingham


FOR PRECISE
PRODUCTION GRINDING
IT'S HARD TO BEAT THE...
Myford
MODEL "MG12"
CYLINDRICAL GRINDER
This machine has established a reputation for high efficiency and low cost, and is now recognized as a BEST BUY.
The MG12 is a manually operated machine for accurate grinding small workpieces, where the actual grinding times are short and automatic movements cannot be fully exploited. Useful for either Toolroom or Production work, it can also save money as a basic auxiliary to larger machines.
GRINDING CAPACITY, 3 × 12 in.
WHEEL SIZE 10 × 1 × 3 in. bore.
WHEEL SPINDLE SPEEDS 2200 and 2500 rpm.
WORK SPEEDS (12) ranging from 75 to 730.
Send for details NOW—
MYFORD ENGINEERING CO. LTD.
BEESTON, NOTTINGHAM, PHONE: BEESTON 25-4222 (3 LINES) GRAMS: MYFORD, BEESTON, NOTTINGHAM.